Creating a High-Resolution Spatially-Explicit Population Distribution

Presented at:: ESRI International Users Conference

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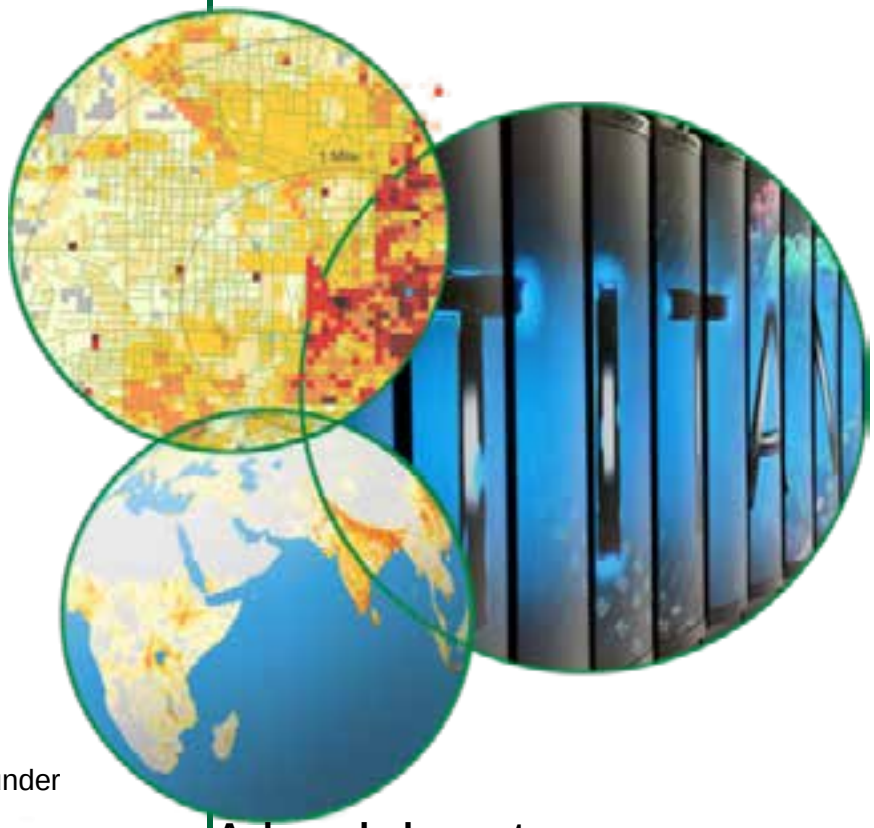
July 17, 2014
San Diego, CA



Acknowledgment
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U.S. DEPARTMENT OF ENERGY

OAK RIDGE NATIONAL LABORATORY
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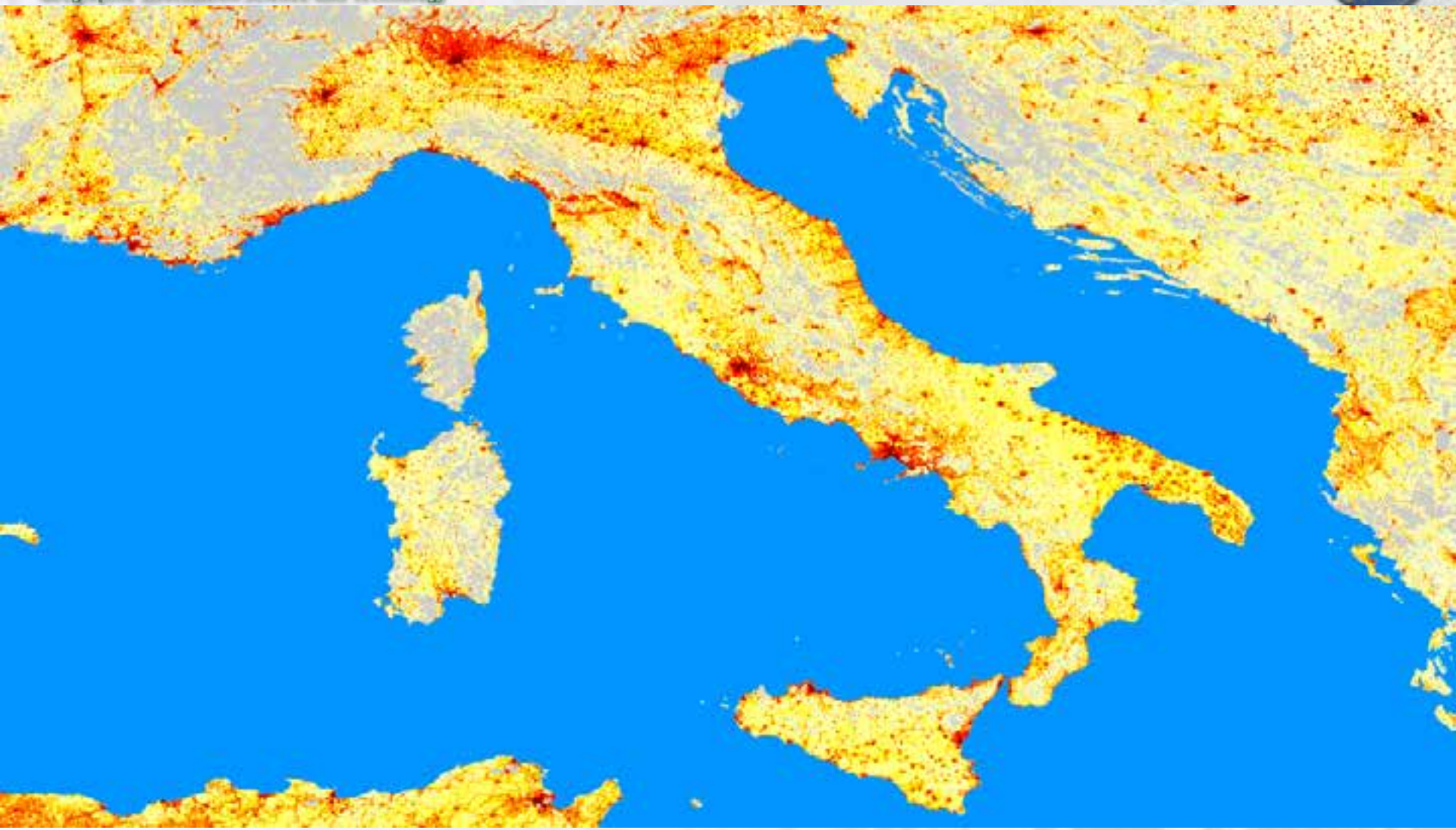
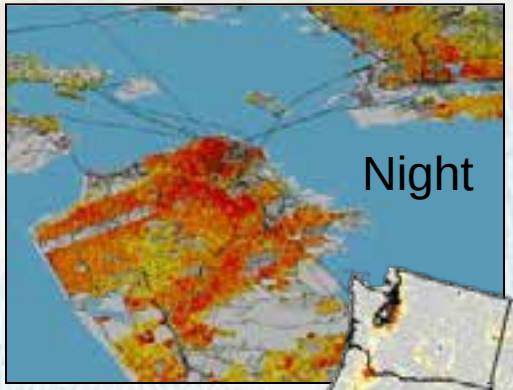
LandScan Global – Historical Developments

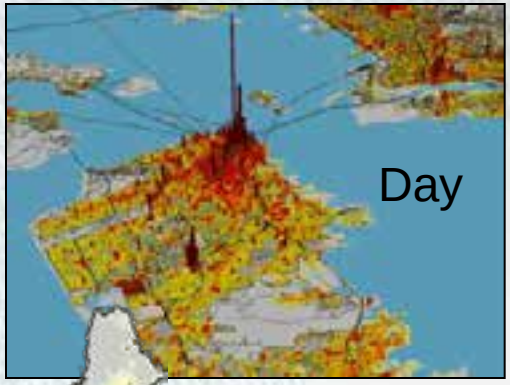


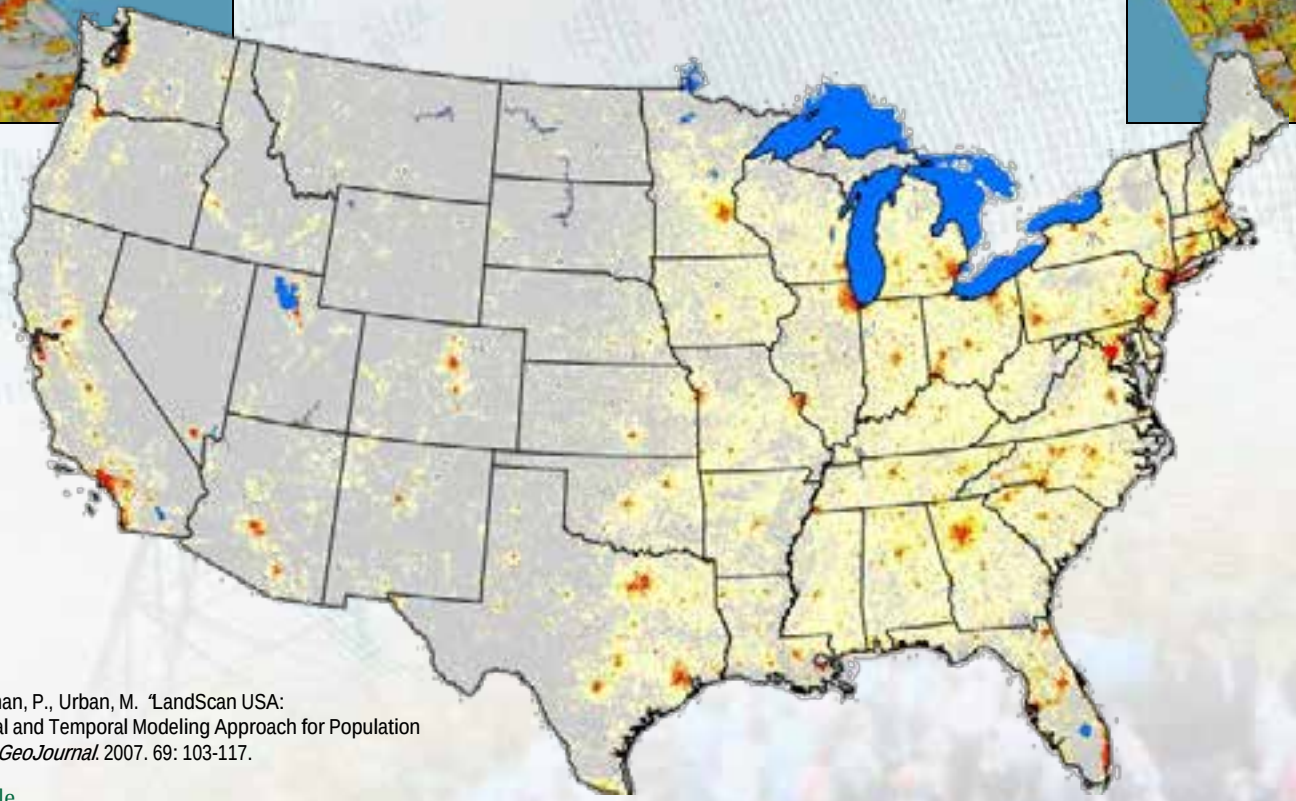
High Resolution Population and Social Dynamics Model

Geographic Information Science and Technology



LandScan USA





Bhaduri, B., Bright, E., Coleman, P., Urban, M. "LandScan USA: A High Resolution Geospatial and Temporal Modeling Approach for Population Distribution and Dynamics" *GeoJournal.* 2007. 69: 103-117.

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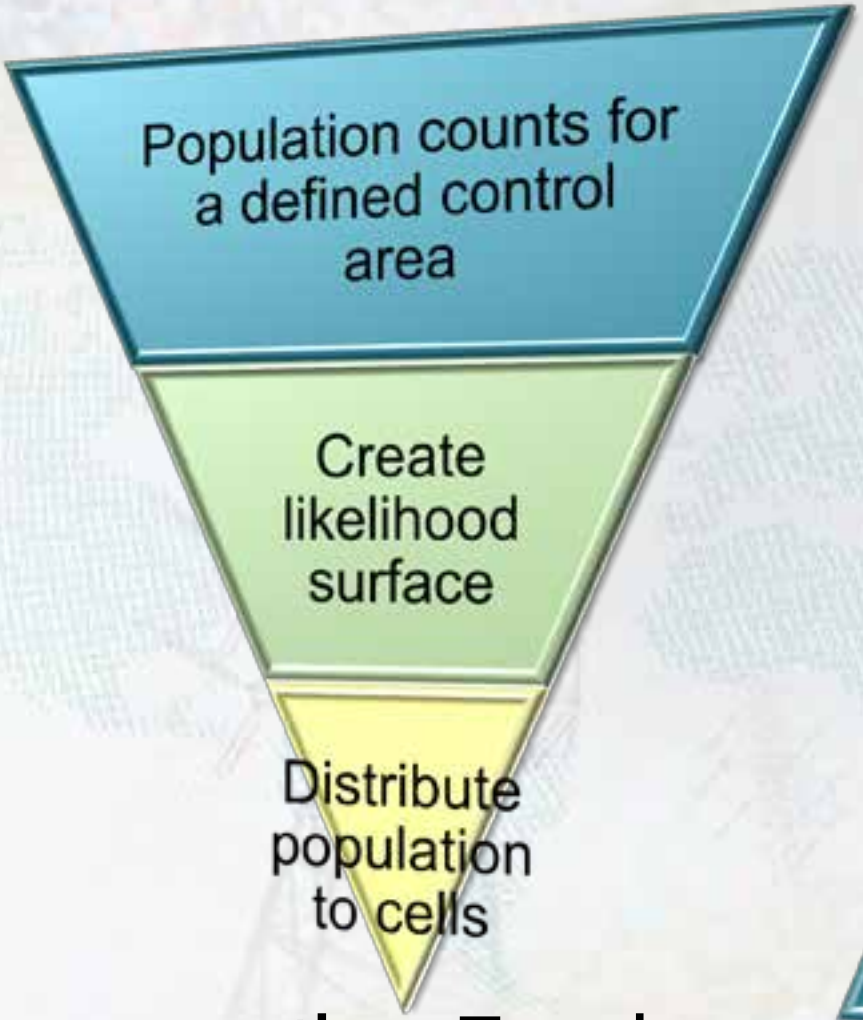
for the Department of Energy

U.S. Patent: 7,247,024. Bright et al., "Method for Spatially Distributing a Population" July 24, 2007.

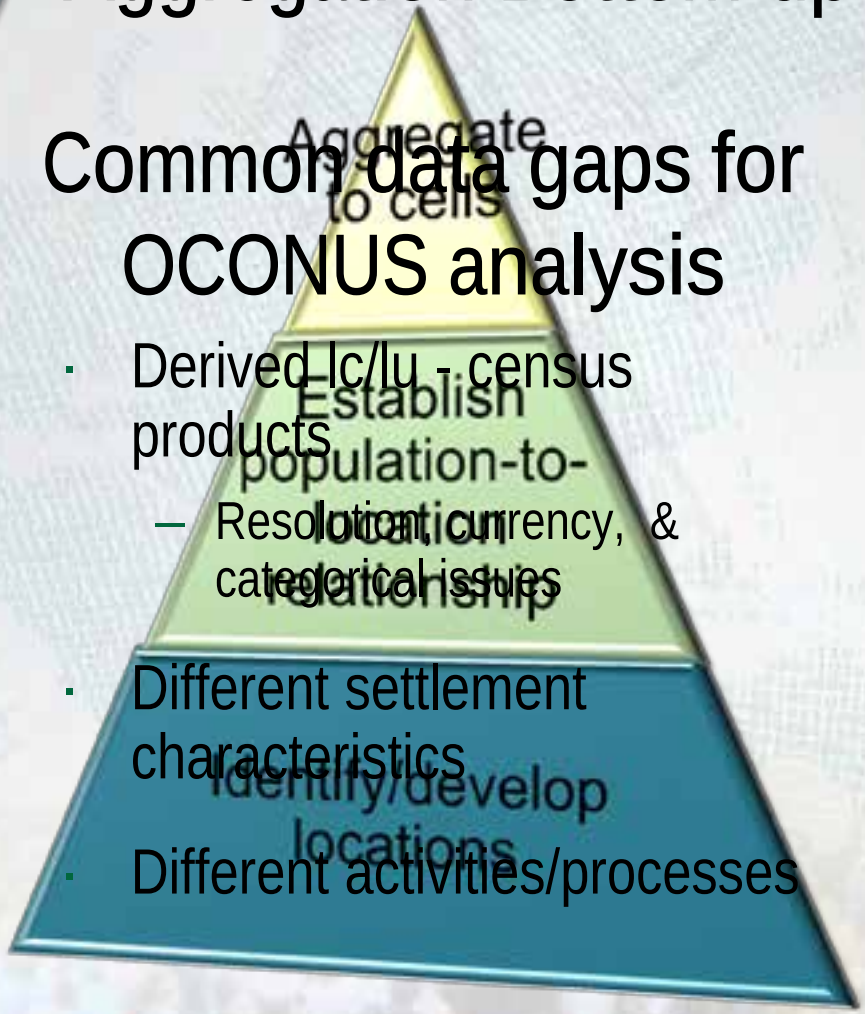

Daytime Population Model
Residential Population Model

Multiple Methodologies



Disaggregation: Top-down

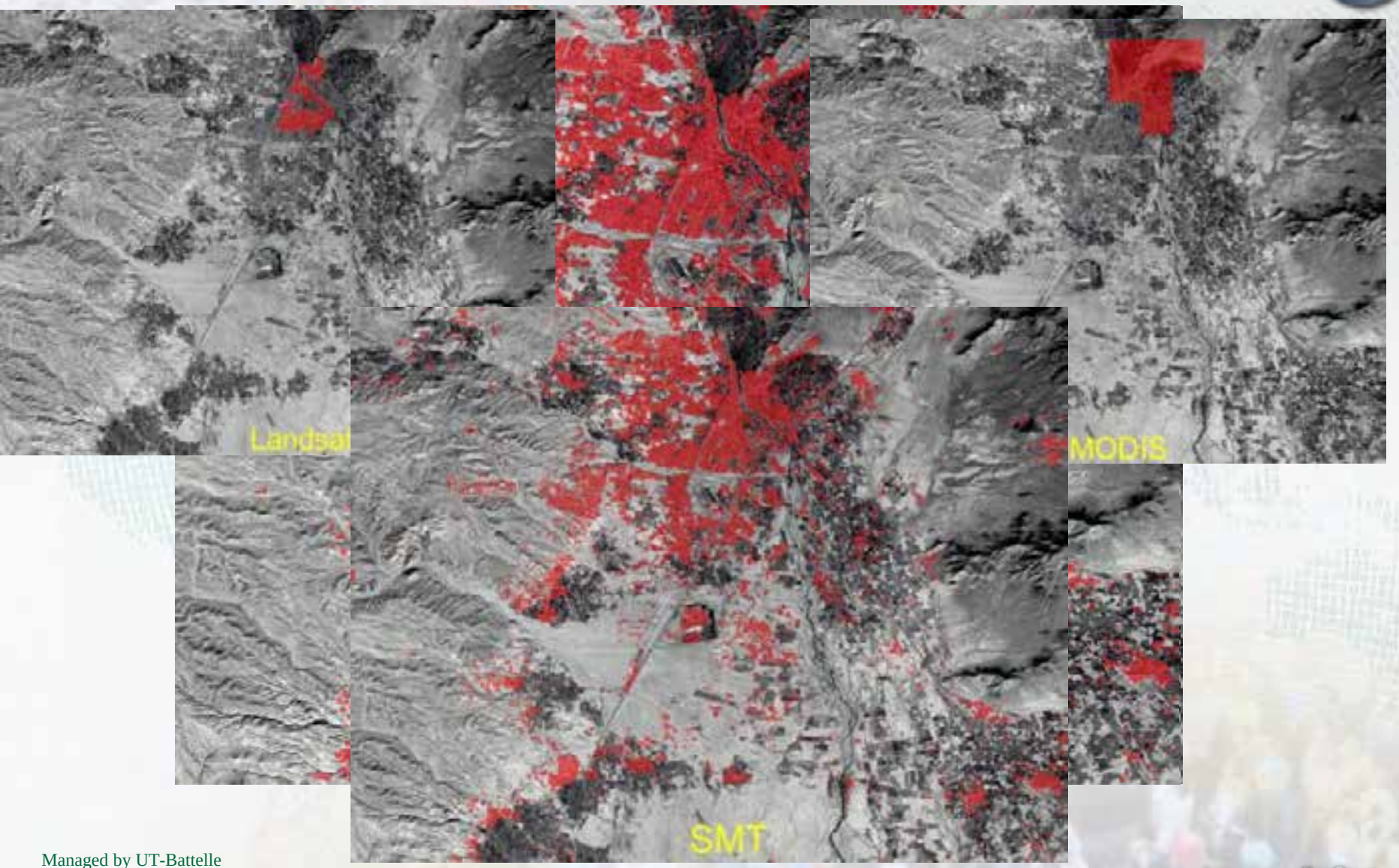
Aggregation: Bottom-up



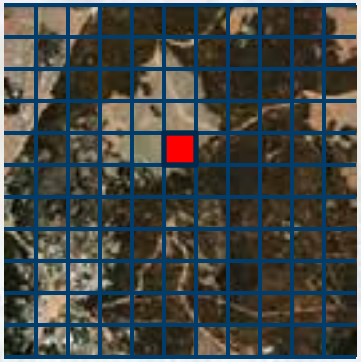
Common data gaps for OCONUS analysis

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

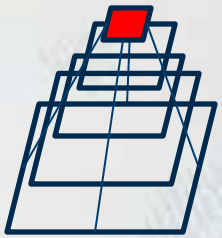
“Developed Land Cover” Examples



Extraction Process



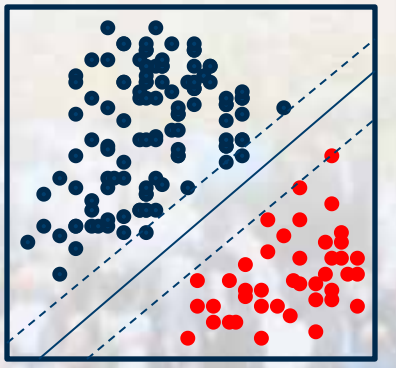
Divide image into pixel blocks



For each pixel block compute multiscale features

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

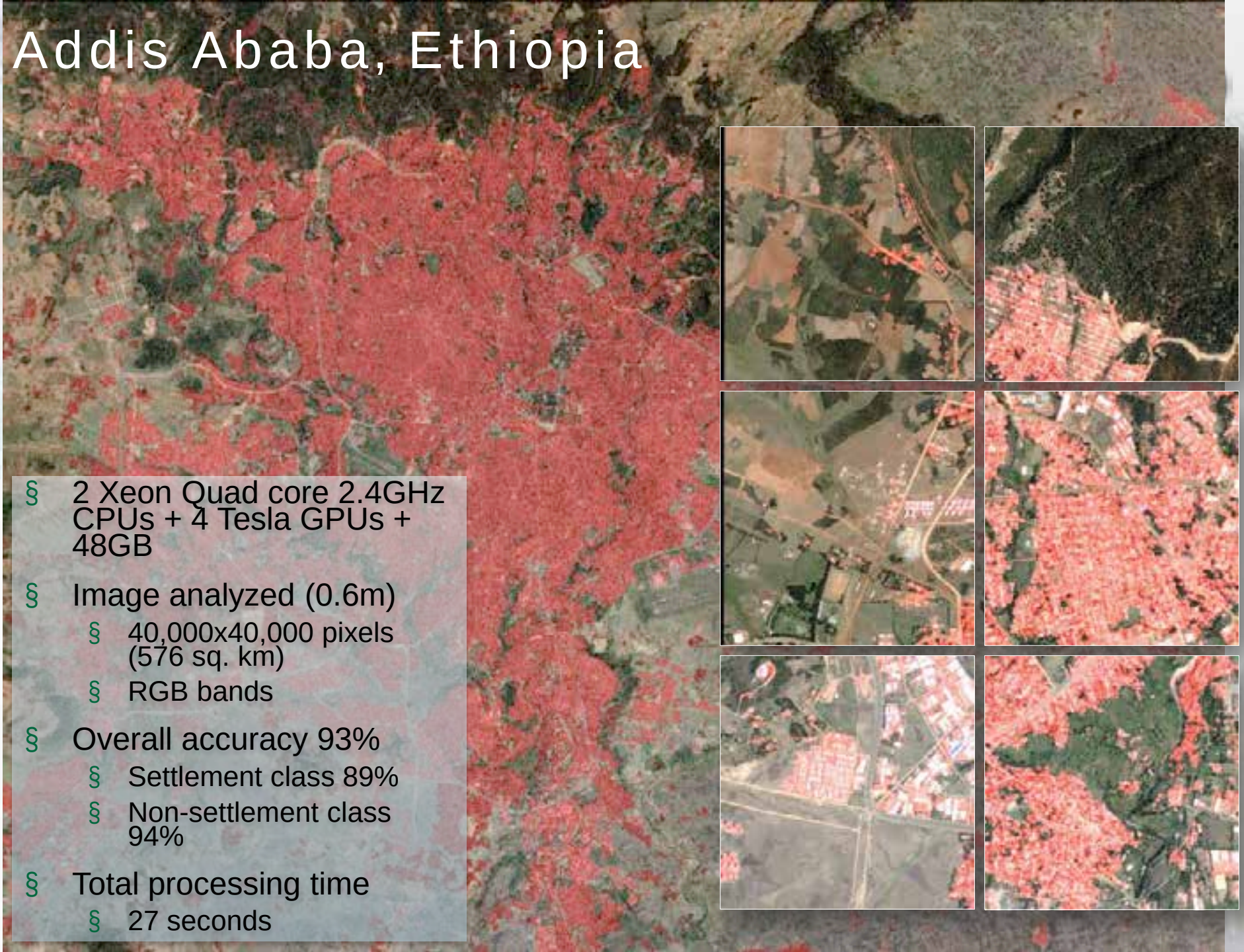
Each pixel block mapped to a multi-dimensional vector



Apply learned linear SVM model

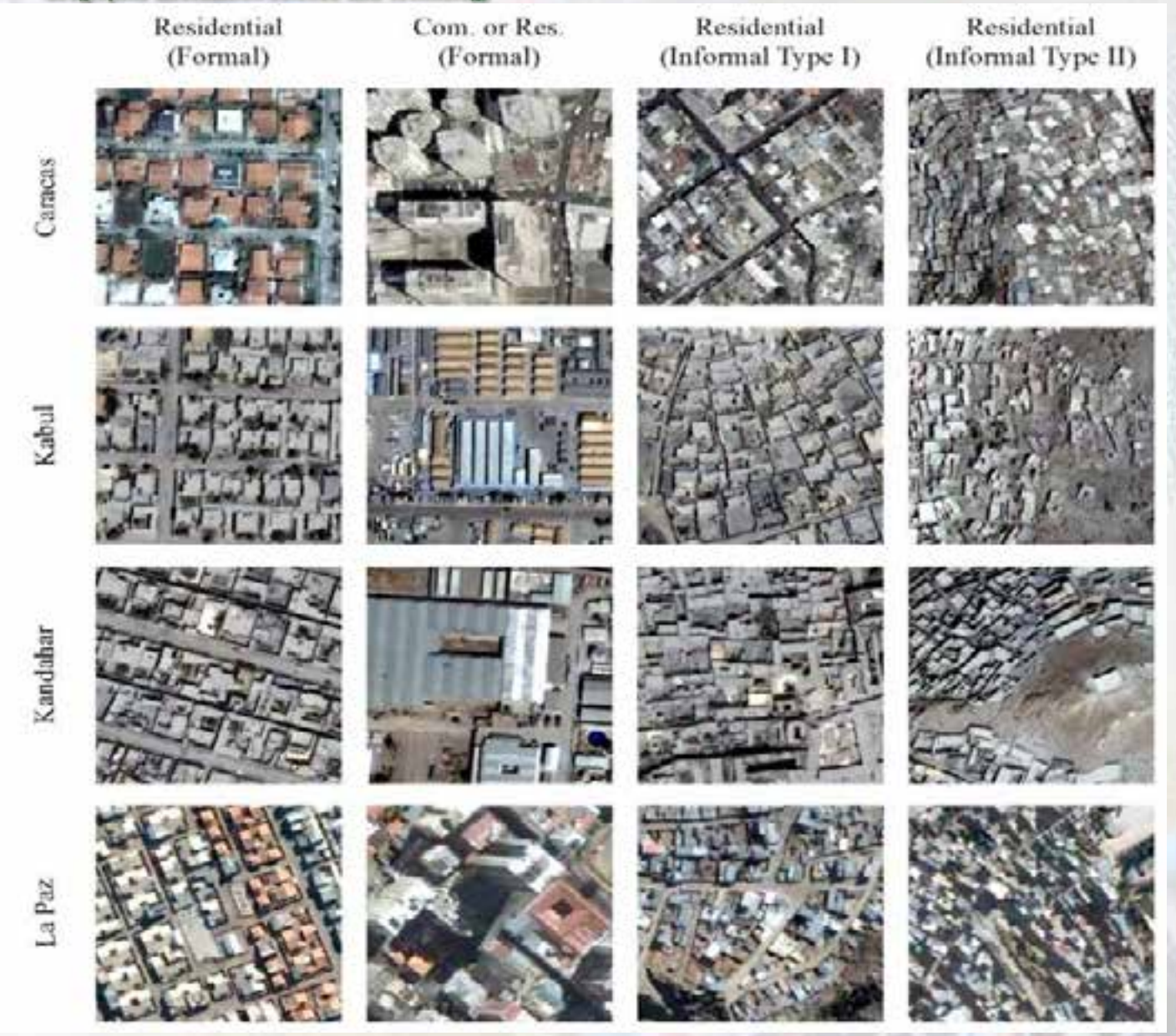
SMTOOL

Addis Ababa, Ethiopia



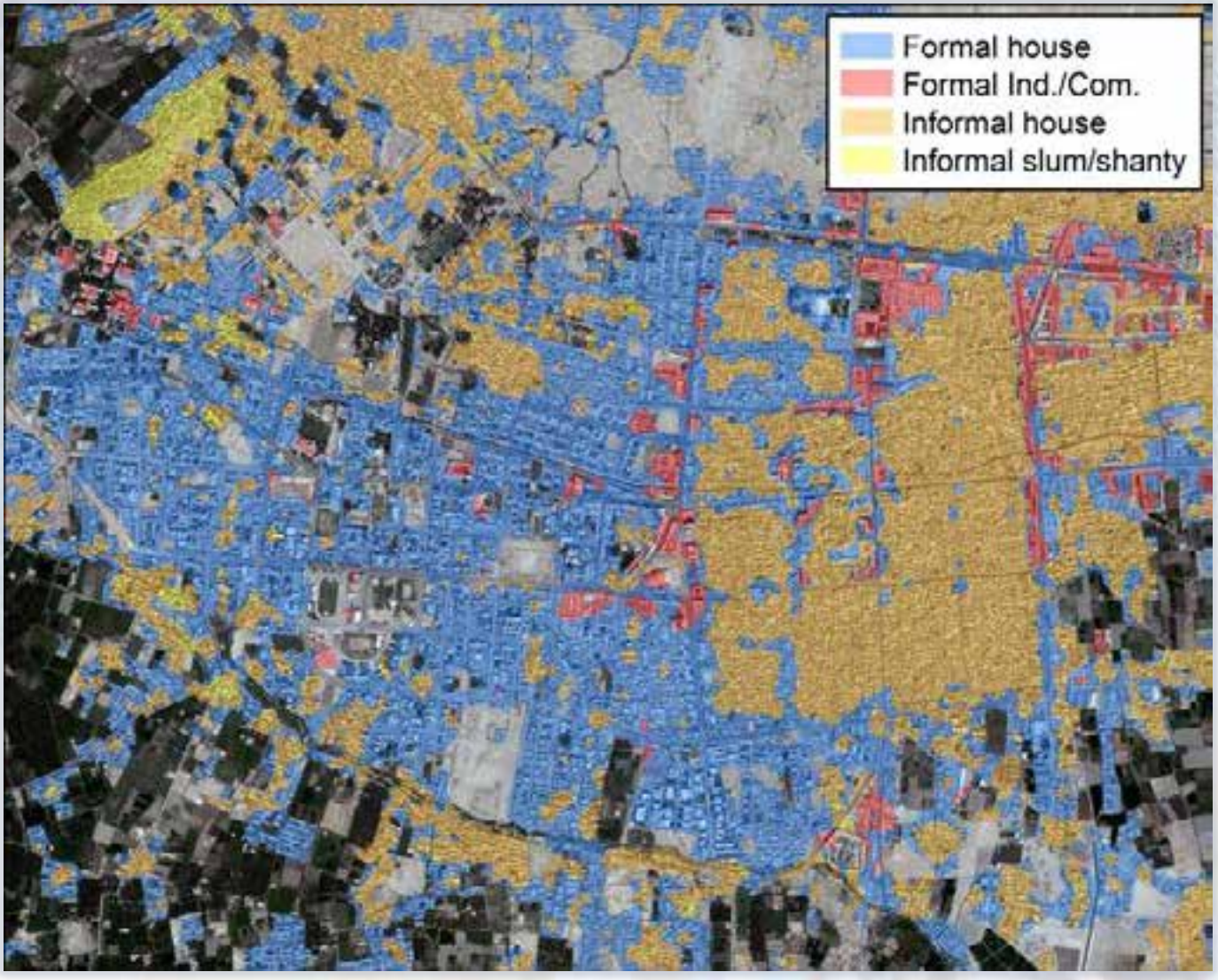
- 2 Xeon Quad core 2.4GHz CPUs + 4 Tesla GPUs + 48GB
- Image analyzed (0.6m)
  - 40,000x40,000 pixels (576 sq. km)
  - RGB bands
- Overall accuracy 93%
  - Settlement class 89%
  - Non-settlement class 94%
- Total processing time
  - 27 seconds

Formal Informal Settlements



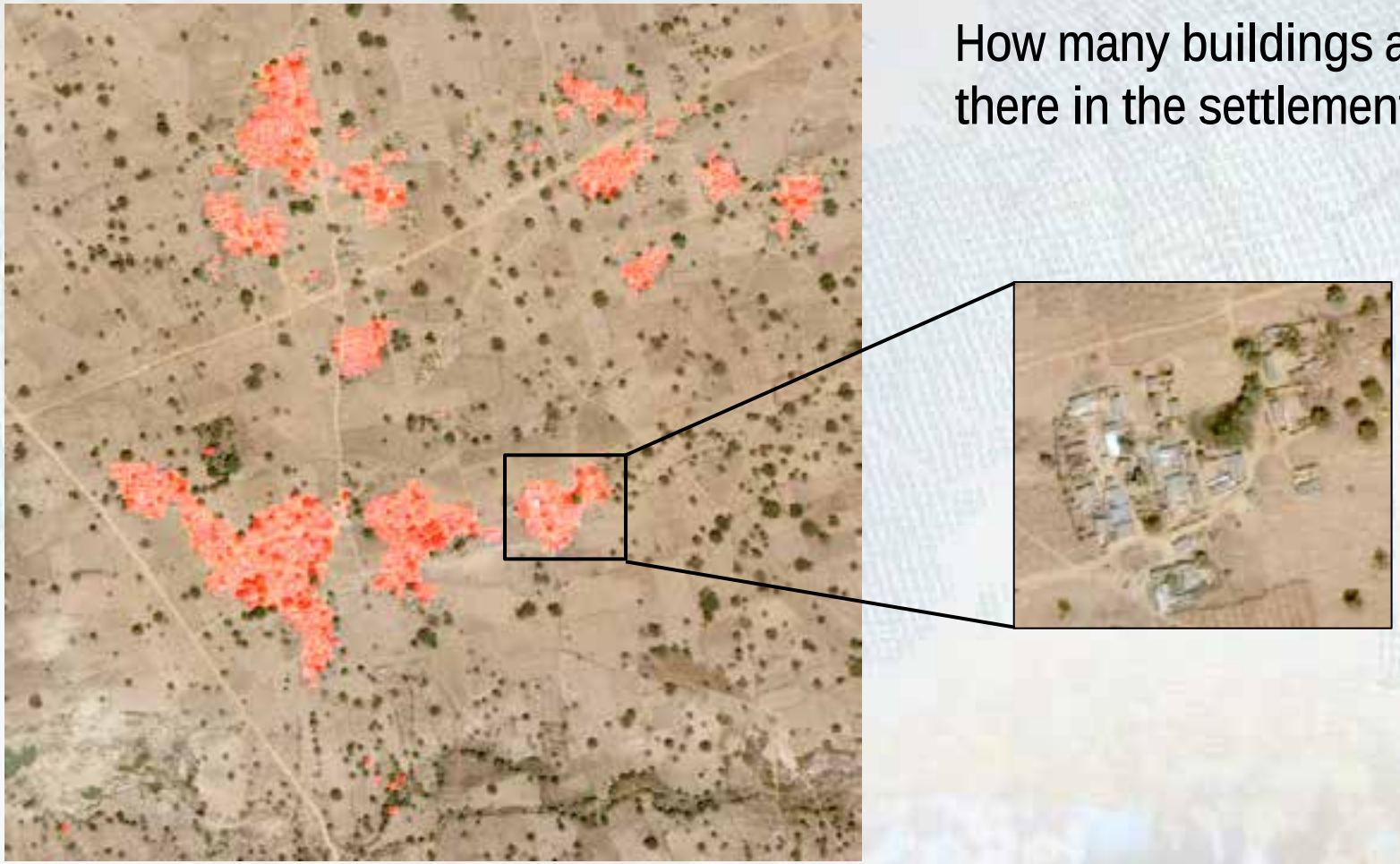
Local geospatial neighborhoods are represented using rich feature descriptors composed of edge, texture, lines and spectral attributes

Formal & Informal Mapping



J. Graesser, A. Cheriyadat, R. R. Vatsavai, V. Chandola, J. Long and E. Bright, "Image Based Characterization of Formal and Informal Neighborhoods in an Urban Landscape ," *EEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 5(4):1164-1176, 2012

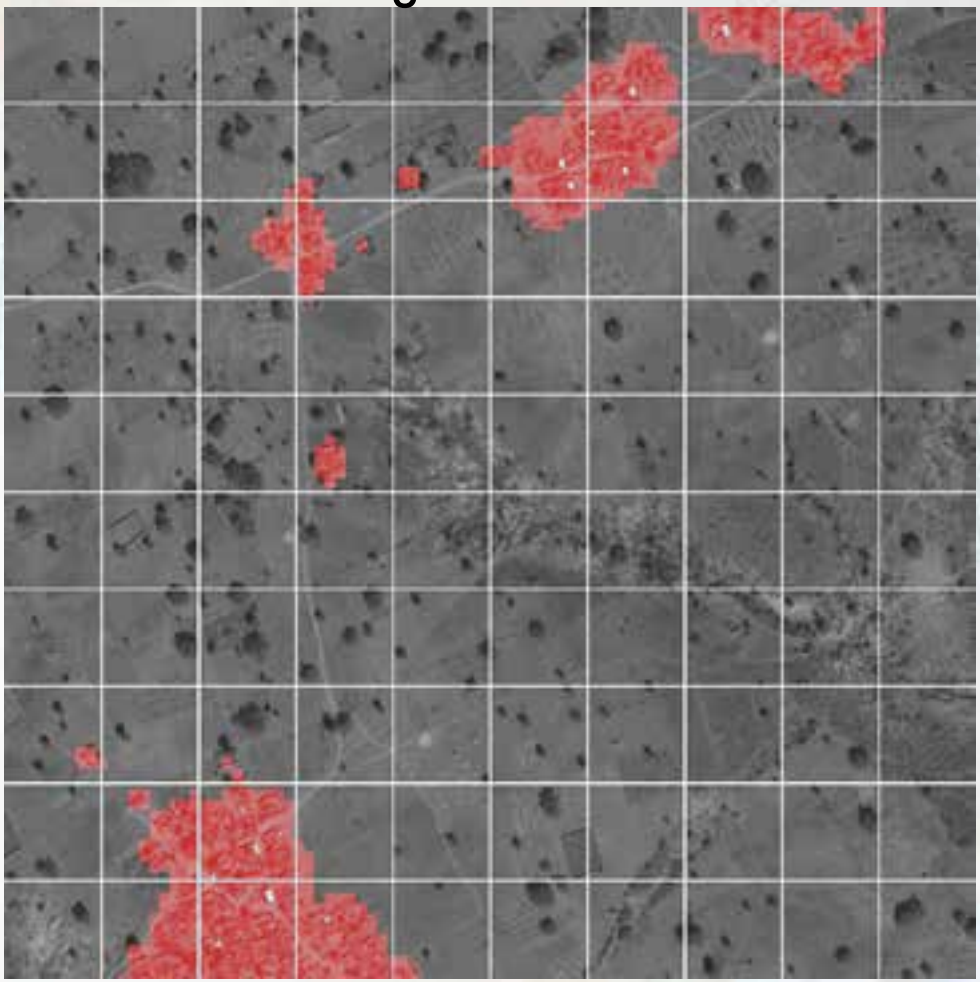
Current Research: Building Density

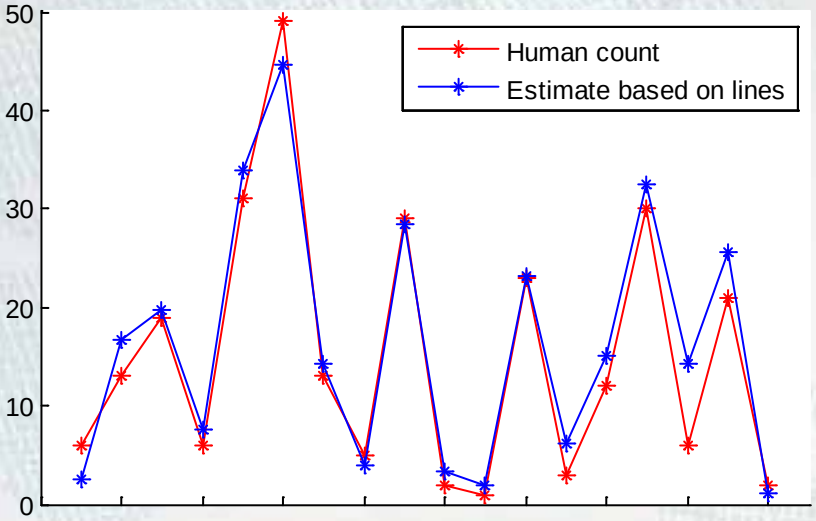


How many buildings are there in the settlement?

Example

- Apply straight line extraction. Line number has a strong linear relation with building number





Example Building Estimates


H:12 A:11


H:42 A:40


H:6 A:5


H:22 A:23


H:12 A:10


H:22 A:26


H:20 A:21


H:29 A:28


H:30 A:25


H:3 A:6


H:5 A:3


H:12 A:11

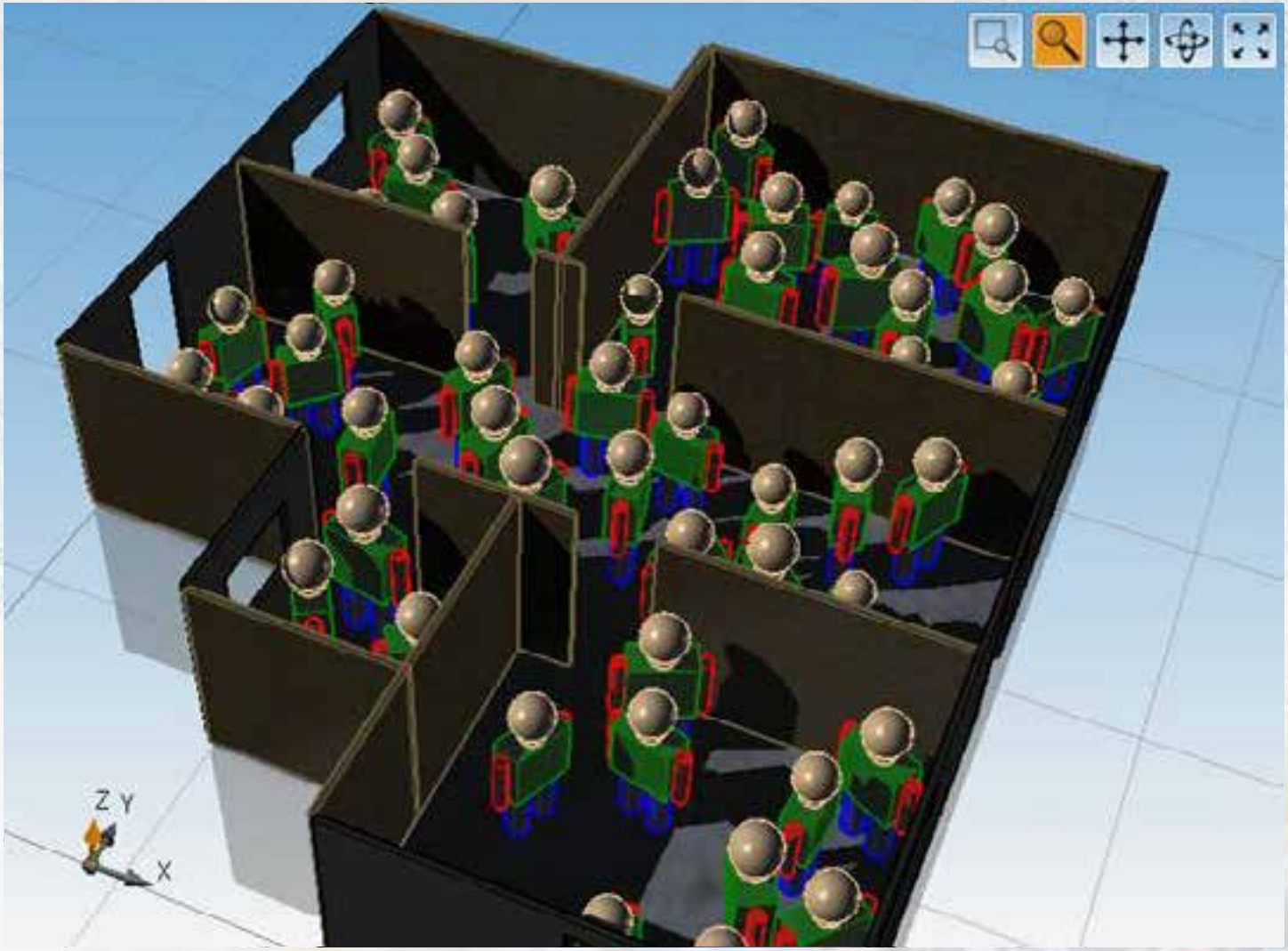

H:4 A:6


H:5 A:5

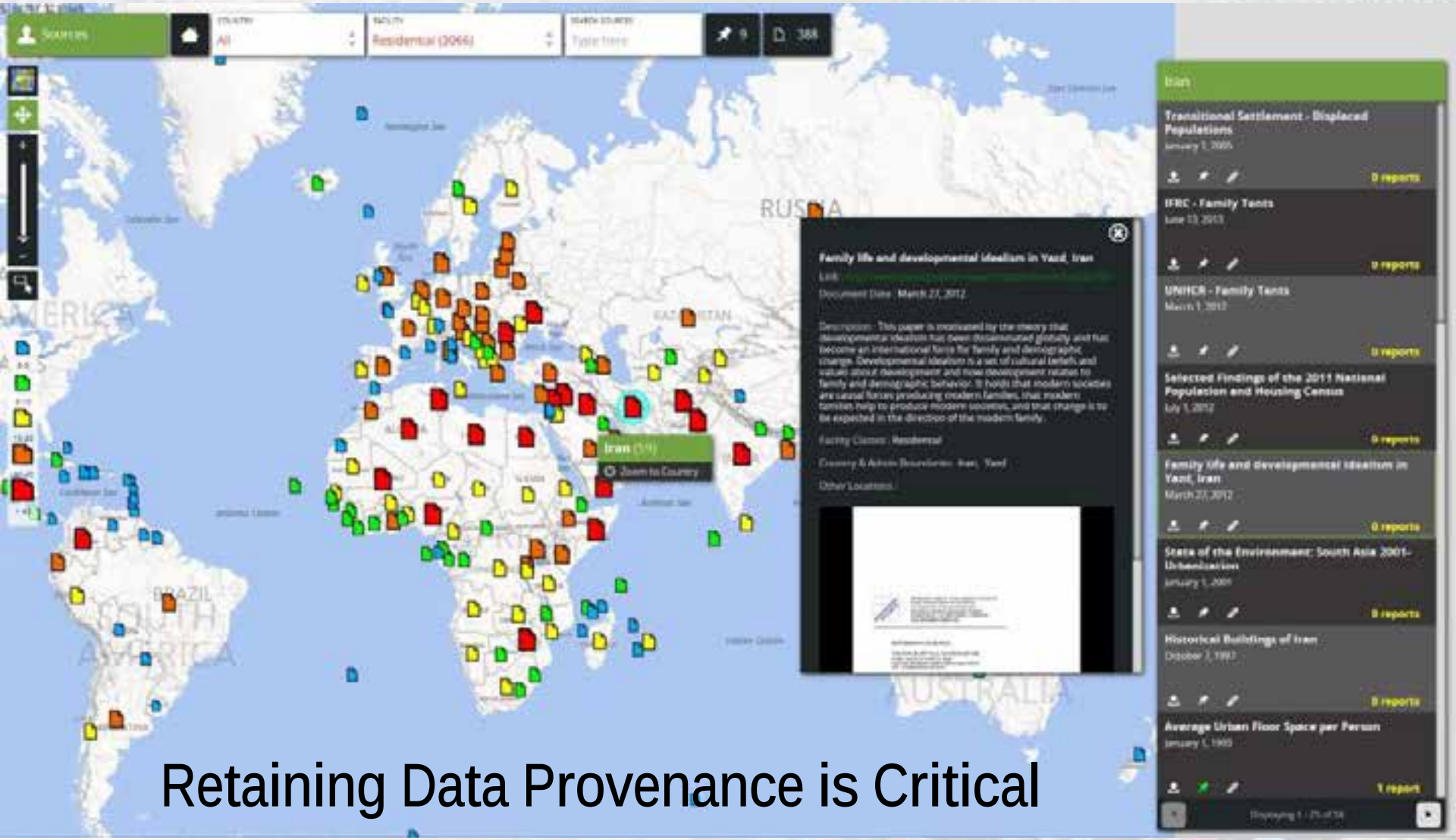

H:7 A:8


H:25 A:33

Building Use, Occupancy & Capacity

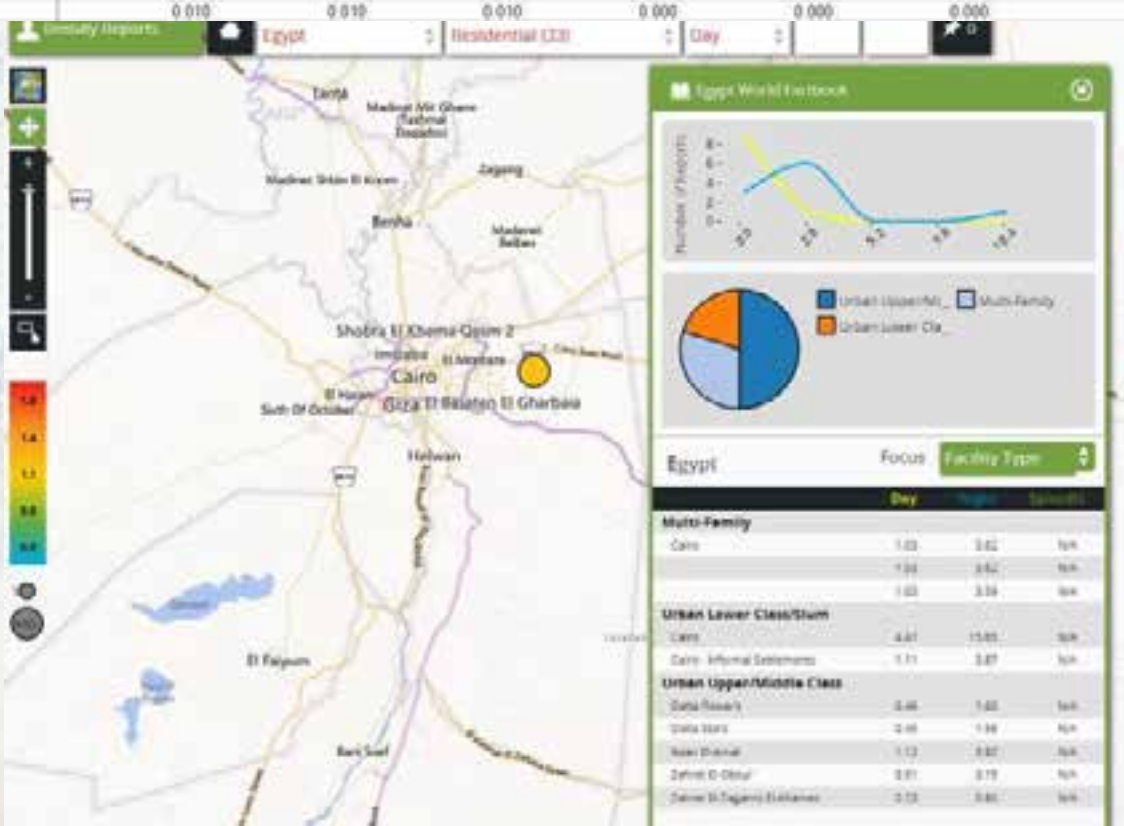


Population Density Data from Open Source



Retaining Data Provenance is Critical

Egypt Downloaded : 03-14-2014	Day-Avg	Day-Min	Day-Max	Night-Avg	Night-Min	Night-Max	Episodic-Avg	Episodic-Min	Episodic-Max
Residential									
Single Family, Urban or Small Town, Upper and Middle Class	0.740	0.230	1.170	2.802	0.000	4.810			
Single Family, Urban or Small Town, Lower Class and Slum	1.932	1.110	4.470	7.120	3.870	16.650			
Single Family, Rural	1.520	1.030	1.800	6.713	3.870	6.770			
Multi-Family Unit (Apartment, Condominium or Dormitory)	1.307	1.030	1.560	4.939	3.590	7.330			
Institutions/Public Service									
Religious							147.724	77.420	238.210
School (Daycare to grade 12)	7.817	5.370	12.320	0.017	0.000	0.040			
College/University	9.606	0.440	21.340	1.163	0.010	8.410			
Hospital/Clinic with beds	6.177	0.930	12.890	3.550	0.679	7.520			
Conference Centers							57.377	8.380	185.810
Jails, Prisons and Detention Centers	82.680	72.260	92.900	82.680	72.260	92.900			
Retail and Service Outlets									
Store/Service Outlet	4.020	3.400	4.650	2.495	2.450	2.540			
Restaurant							67.360	67.360	67.360
Hotel/Motel	1.656	0.280	2.980	2.071	0.310	3.400			
Commercial									
Light Manufacturing	4.783	0.850	10.410	0.334	0.070	0.850			
Heavy Manufacturing	1.773	1.390	2.010	0.287	0.070	0.680			
Chemical, Refining, Cement	1.160	1.160	1.160	0.060	0.060	0.060			
Recreation/Entertainment									
Theater							79.373	57.290	106.780
Outdoor Intensive (Stadium or Racetrack)							13.630	13.630	13.630
Night Club							178.660	178.660	178.660
Agriculture									
Indoor	2.240	1.200	3.830	0.117	0.060	0.200			
Outdoor	0.010	0.010	0.010	0.000	0.000	0.000			



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OSM Data in the Developing World

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

World Environment 2013, 3(2): 45-51
DOI: 10.5923/j.env.20130302.02

Slum Prevalence in Nigeria: What Role for Architects?

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Department of Architecture, Federal University of Technology, Akure, 340001, Nigeria

Table 1. Slum Prevalence in Nigerian Cities

S/No	Nigerian Cities	Slum Areas
1	Lagos	Ajegunle, Makoko, Agege, Bariga, Badia, ilaje, Ijeshatedo/ Itire, Iwaya, Amukoko
2	Kano	Kurna Asebe, Sabon gari, Nassarawa,
3	Ibadan	Beere, Oje, Inalende, Mapo, Oke-Padi, Yemetu, Oniyanrin, Agbokojo, Akobo- Ojuirin, Bodija, Ojoo
4	Akure	Erekesan, Obanla, Isolo, Idiagba/Ijemikin
5	Kaduna	Angwar Kurmin Gwari, Television, Nasarawa, Angwar Shanu
6	Jos	Bayan Rogo, Gangare, Katako, Angwan Rukuba
7	Enugu	Akwuke, Ugwuaji, Abakpa, Emene, Akegbeugwu
8	Port Harcourt	Njemanze, Igbo-etche, Bundu Waterside, Mile 1, Eleme
9	Ado Ekiti	Oke –Isa, Irona, Oke-Ila
10	Abuja	Dutsen Alhaji, Karinnu, Gwagwa, Kabusa, Kuchi Bena
11	Minna	Tudun Fulani, Kpakungu, Angwan Biri, Dutsen Kura
12	Makurdi	Wadata, Agwan Jukun, Idye, Logo
13	Zaria	Parts of Samaru, Hagin Dogo

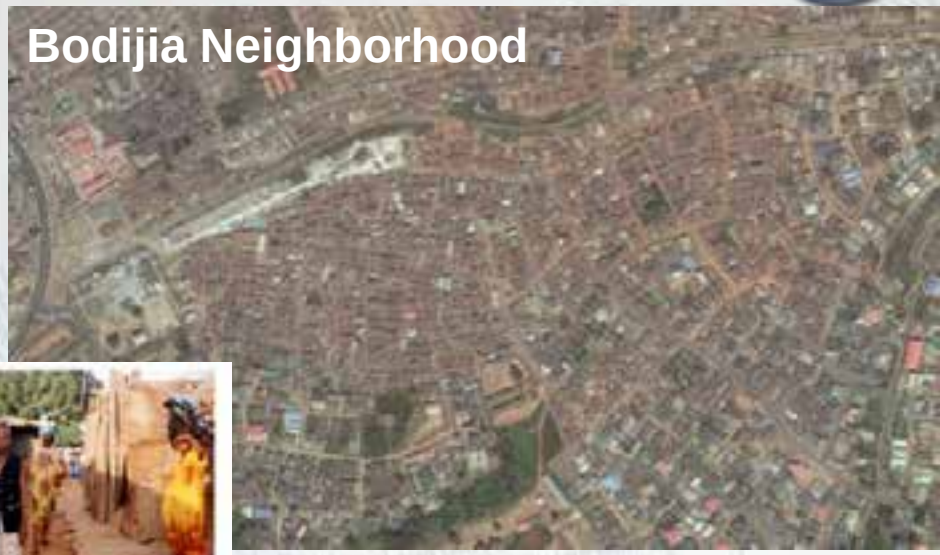


Plate 3. Street in Bodija Market slum. Toilets are on the right, houses, on the left. Source [7]

Plate 2. Crowded houses opposite stakeshift wooden houses in Ojoo, Ibadan. Source [7]

Field Observations

- Conducted in 5 cities across Nigeria

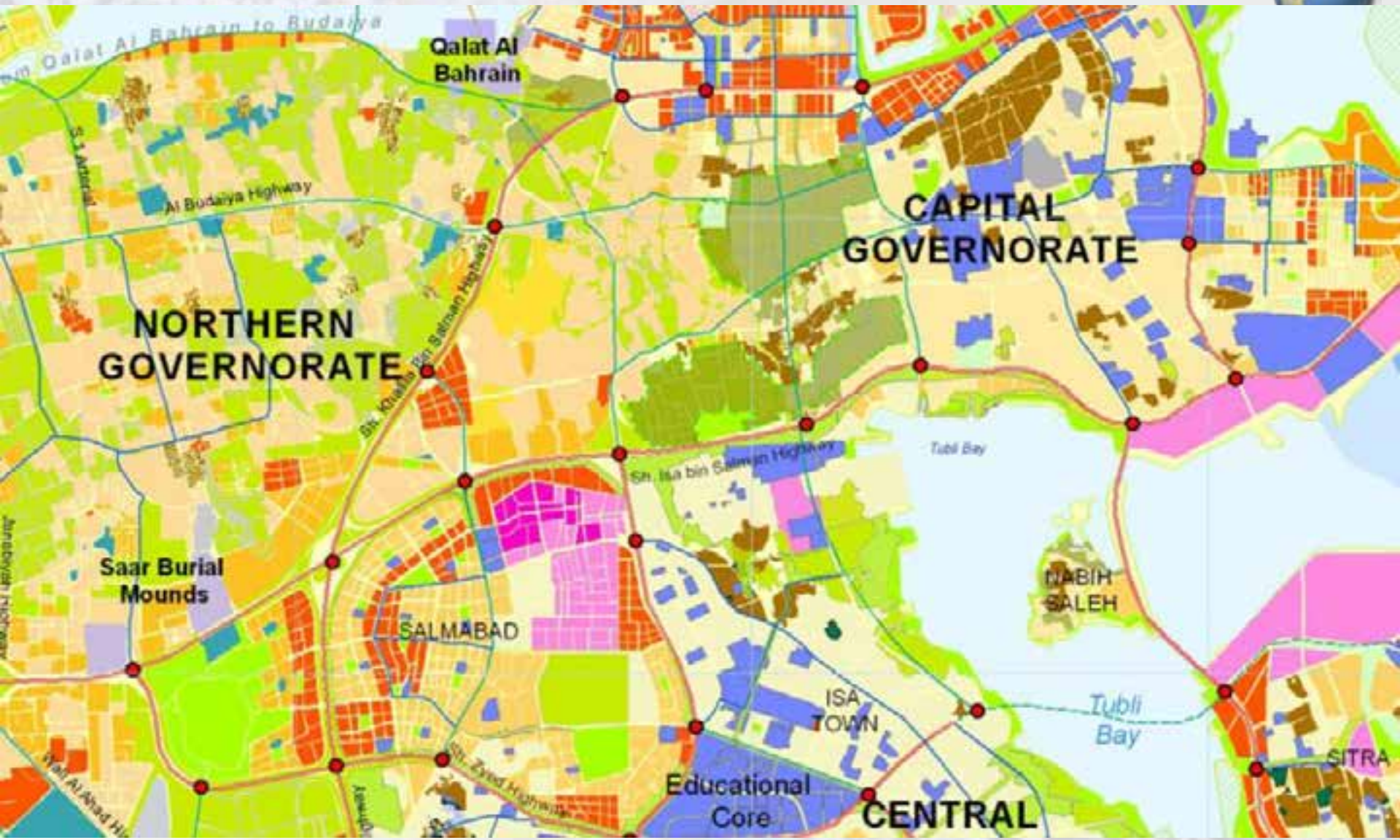
HOSPITAL

					Occupancy										Additional Cultural Insights
					Monday-Friday		Saturday-Sunday		Holidays						
Type	Facility Name	Area	# of floors	Composition	Day	Night	Day	Night	Day	Night	What type of hospital is this (public, private, general, specialty, etc)? Who owns/operates it?	How many beds does it have? How many are typically occupied?	What days of the week is the hospital busiest? What time of day? Why?	What times of year is the hospital busiest (e.g., particular seasons, holidays, etc)? Why?	What types of people are admitted to this hospital (e.g., men/women, young/old, lower/middle/upper class, people with certain types of ailments/injuries)?
Hospital	Mokama Hospital	Unwell	3	Built of concrete blocks, reinforced pillars, and columns, white painted walls and ceilings	750 People 7:00-7:00pm	100 People 7:00pm-7:00am	750 People 7:00-7:00pm	100 People 7:00pm-7:00am	750 People 7:00-7:00pm	100 People 7:00pm-7:00am	Private/Government partnership facility. Some patients pay a fee while many get free medical attention. It is operated by a board of trustees overseen by the government. The hospital has many offices, wards, clinics, labs, and specialized equipment.	50 beds, all occupied	Mon - Fri between 8:00am and 5:00pm. There are times when many patients and workers would be coming and going.	When schools are reopening. Many children come for check ups and hospital reports.	People of all walks of life, genders, and ages.
Hospital	National Hospital	Unwell	2	Concrete Blocks	400 People 7:00-7:00pm	200 People 7:00pm-7:00am	400 People 7:00-7:00pm	200 People 7:00pm-7:00am	400 People 7:00-7:00pm	200 People 7:00pm-7:00am	Publicly managed by the Government.	200 beds, all occupied	Mon - Fri	Rainy season, when many get sick and there are many accidents.	People of all walks of life, genders, and ages.

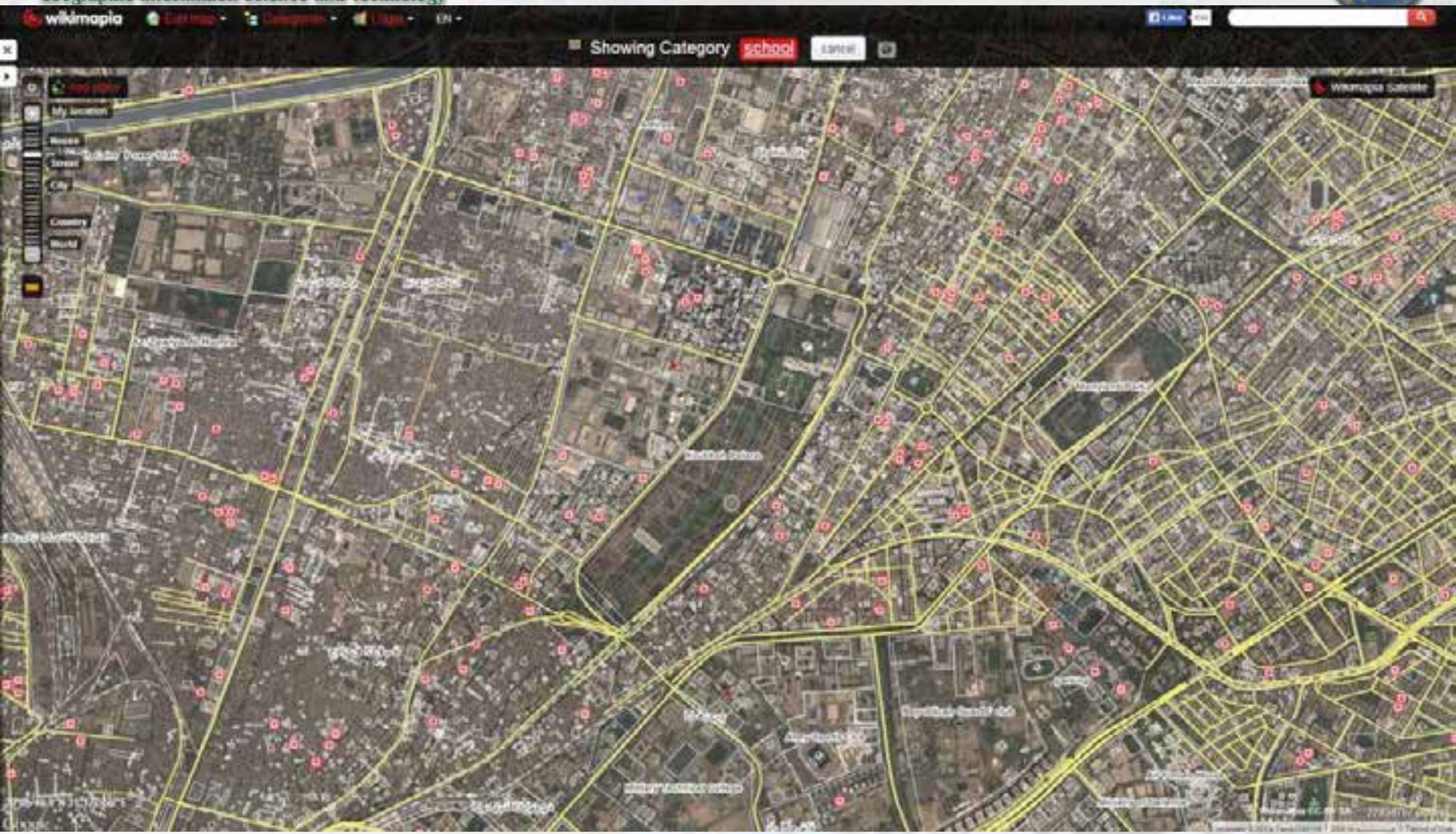
Open Street Map Location

Wikimapia Location

Open Source Data Mining: Zoning

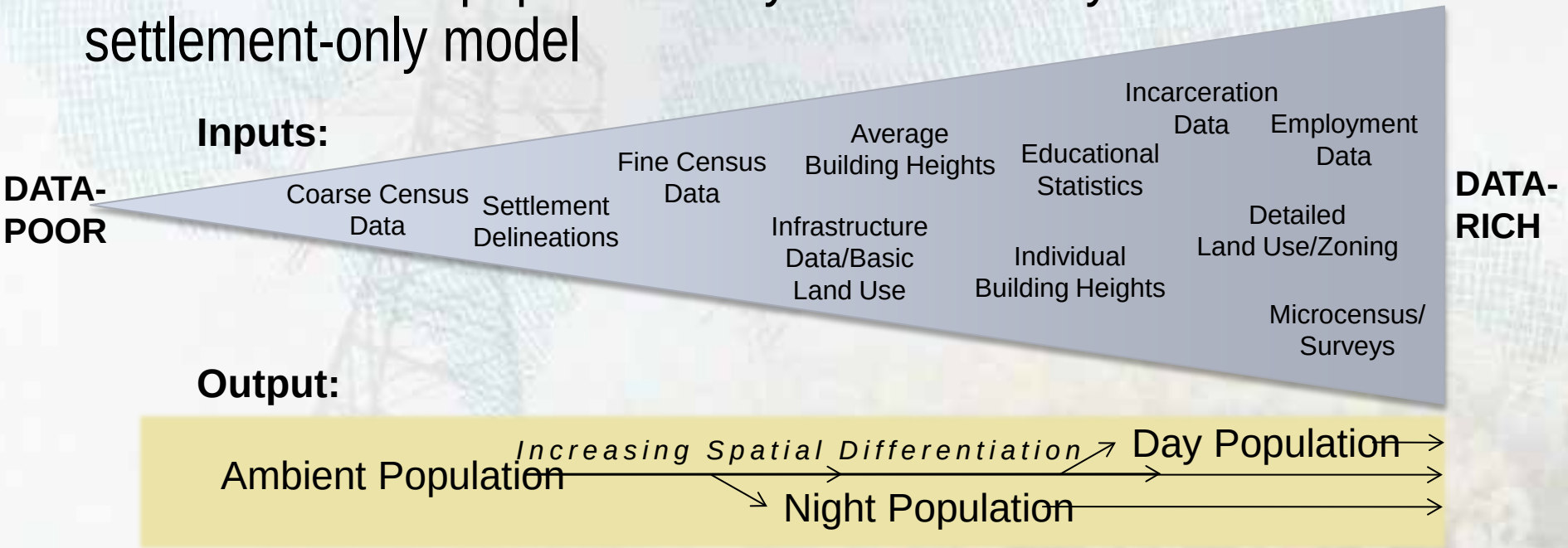


VGIS Data

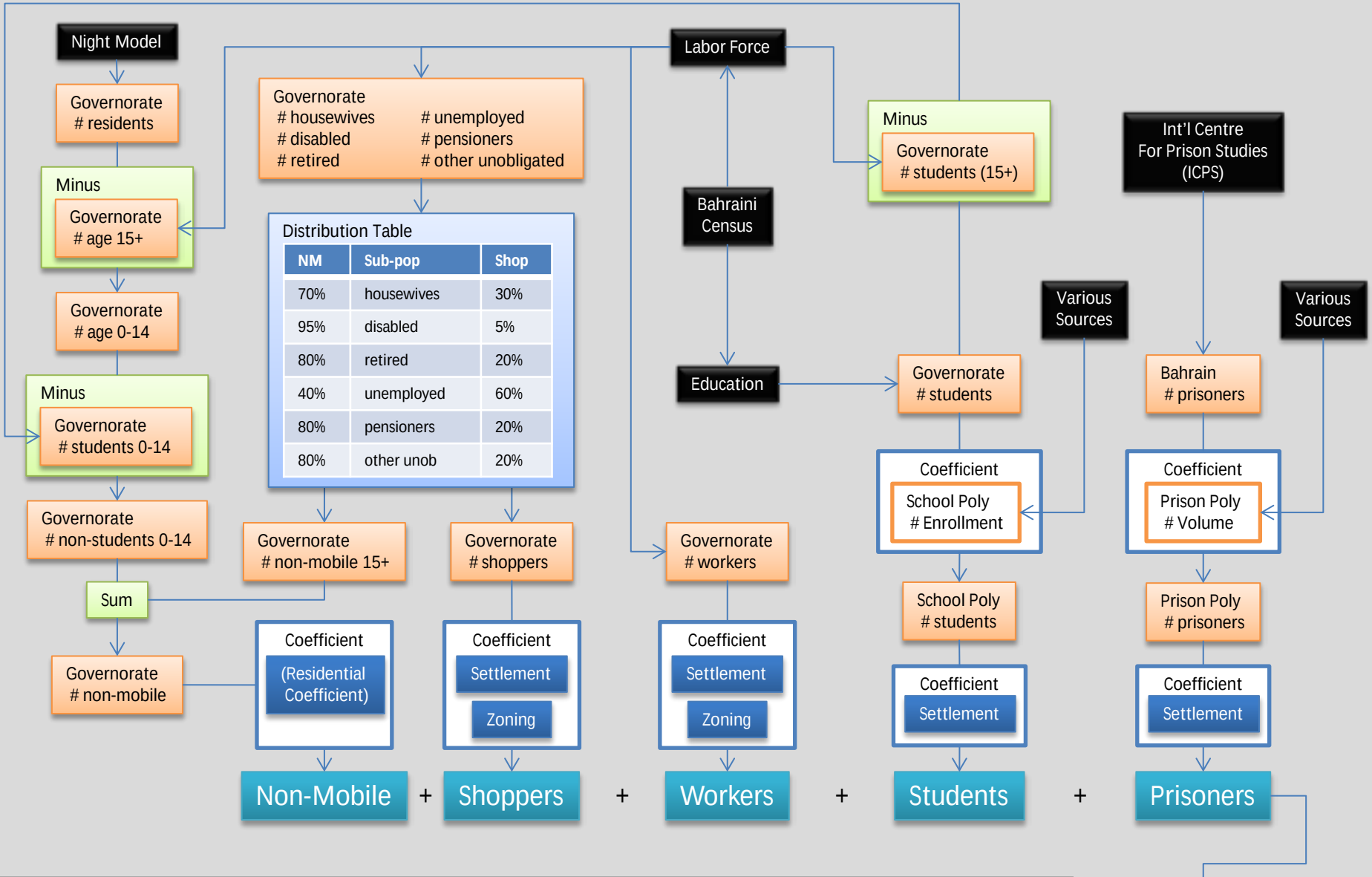


LandScan HD Population Modeling

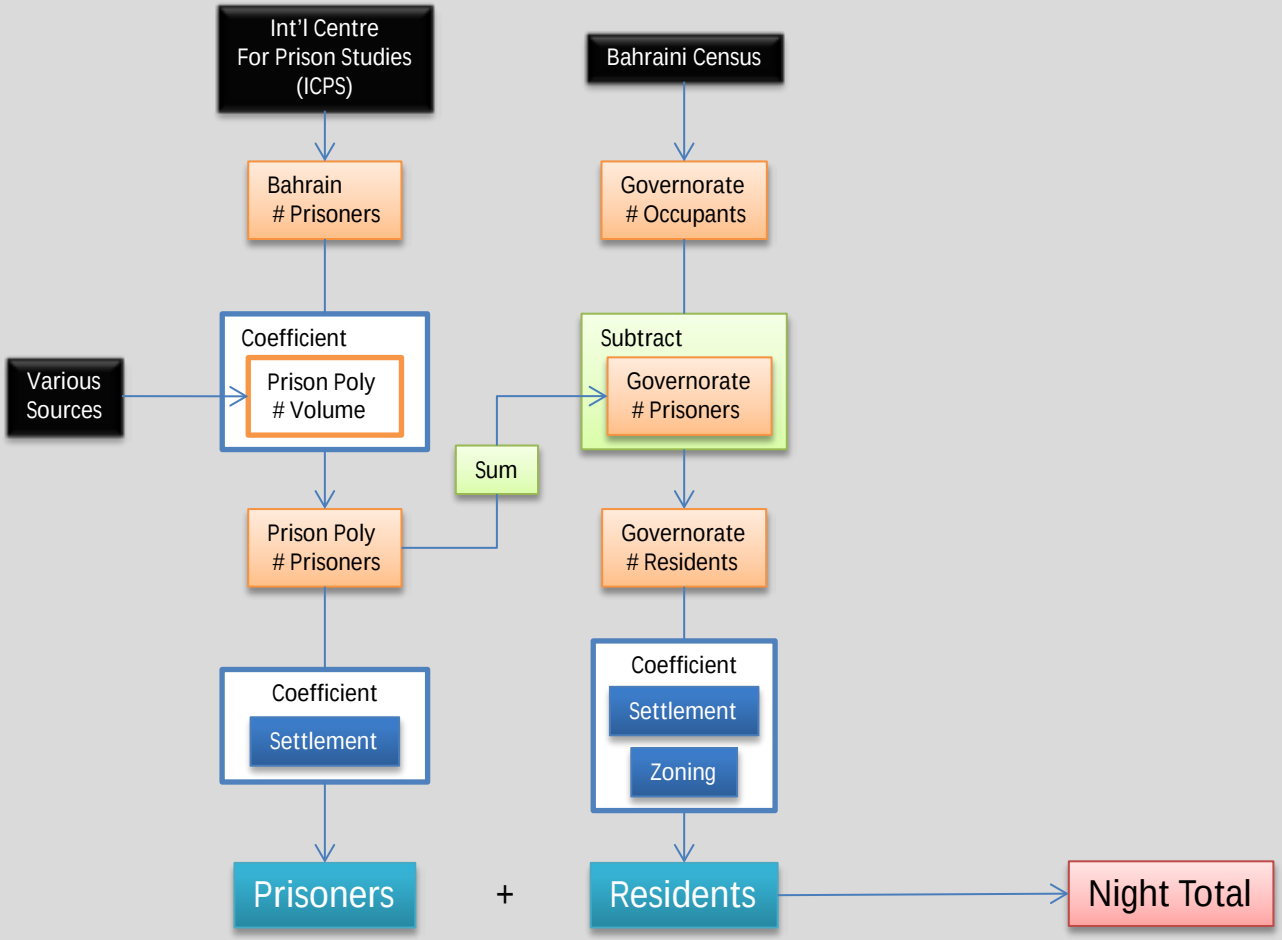
- Beyond the core population and settlement inputs, the availability, completeness, and level of detail of relevant ancillary data determines the model complexity for an area
- Useful ancillary data increases the spatial or temporal differentiation of population beyond the binary settlement-only model



Bahrain Day Model



Bahrain Night Model



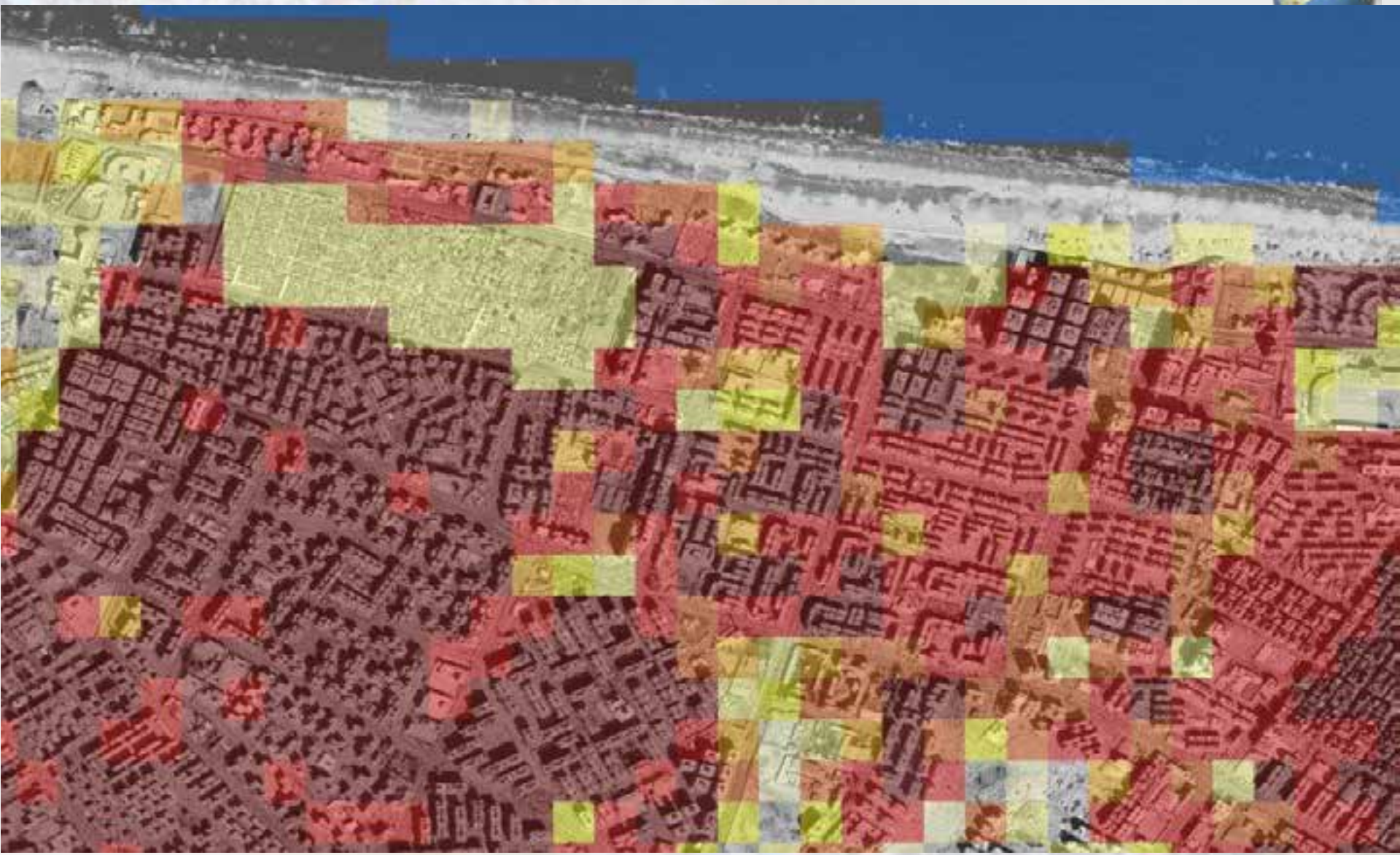
Key:

- Boundaries # Component Population
- Boundaries # Value used in calculation
- Coefficient Component
- Operator/Calculation
- Data Source
- Total Population Raster
- Component Population Raster

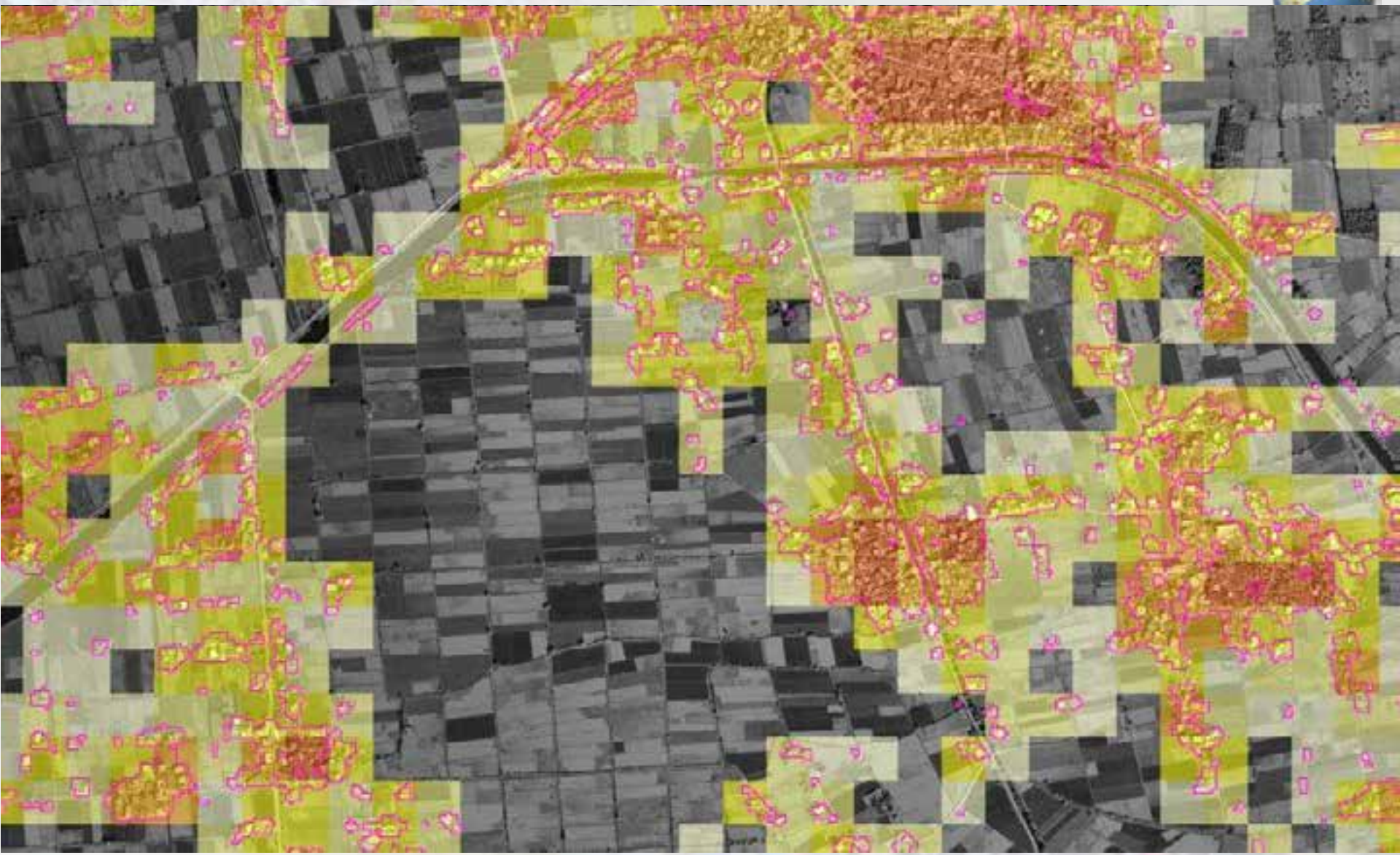
LandScan HD - Bahrain

Geographic Information Science and Technology

Port Said



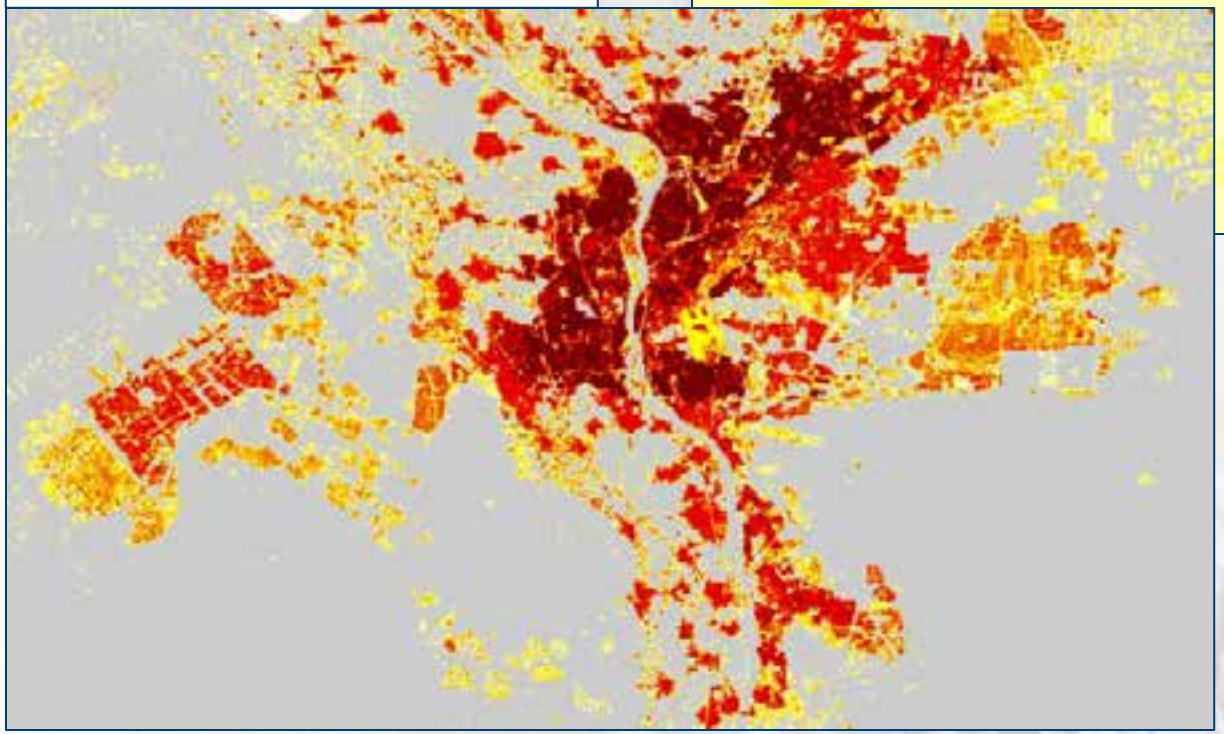
Ismailia - Rural

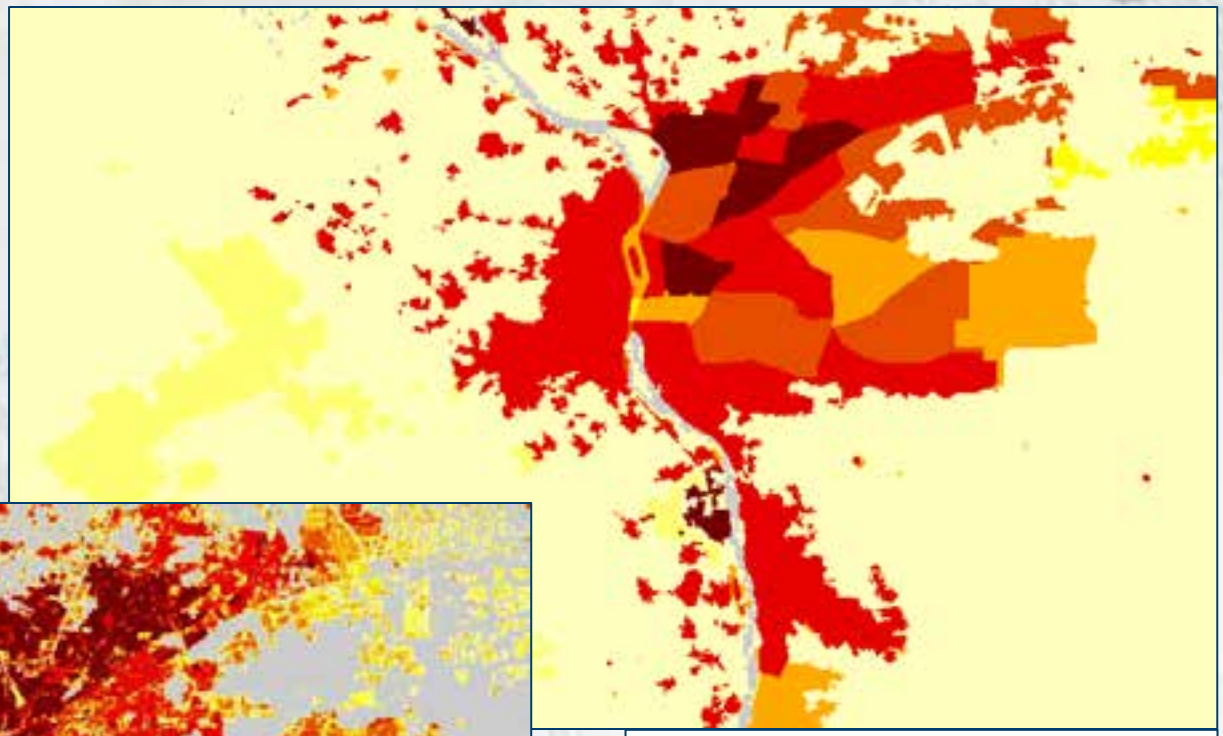


LandScan HD is Spatially Explicit

Cairo, Egypt

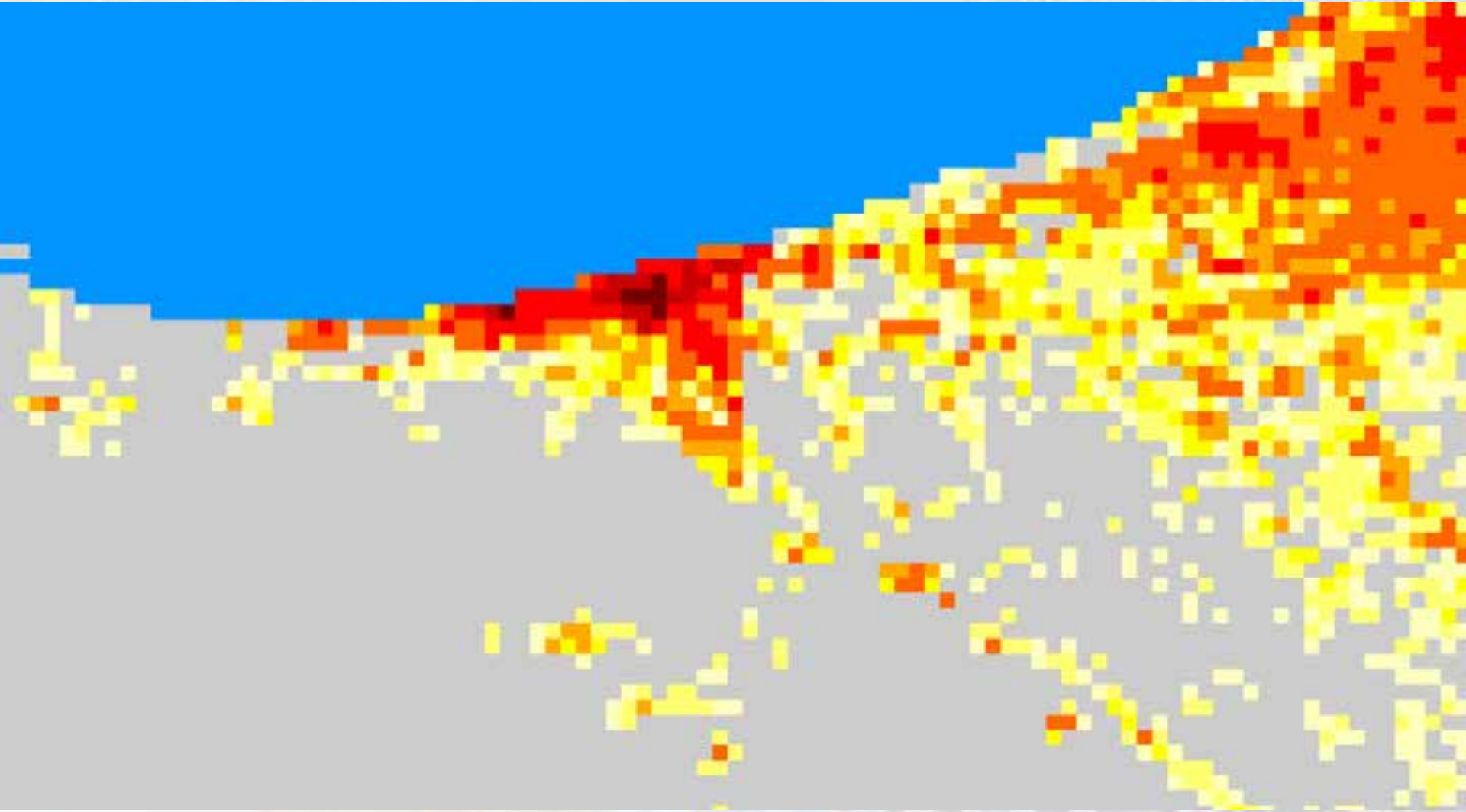
LandScan HD
3 arc-second resolution
(~90m)





AfriPop
100m resolution

LandScan HD: Impact on LandScan Global



Questions?

www.ornl.gov/LandScan

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