

Improving earthquake risk assessments for the reinsurance industry using remote sensing and socioeconomic data

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Joint Project with ImageCat Inc.

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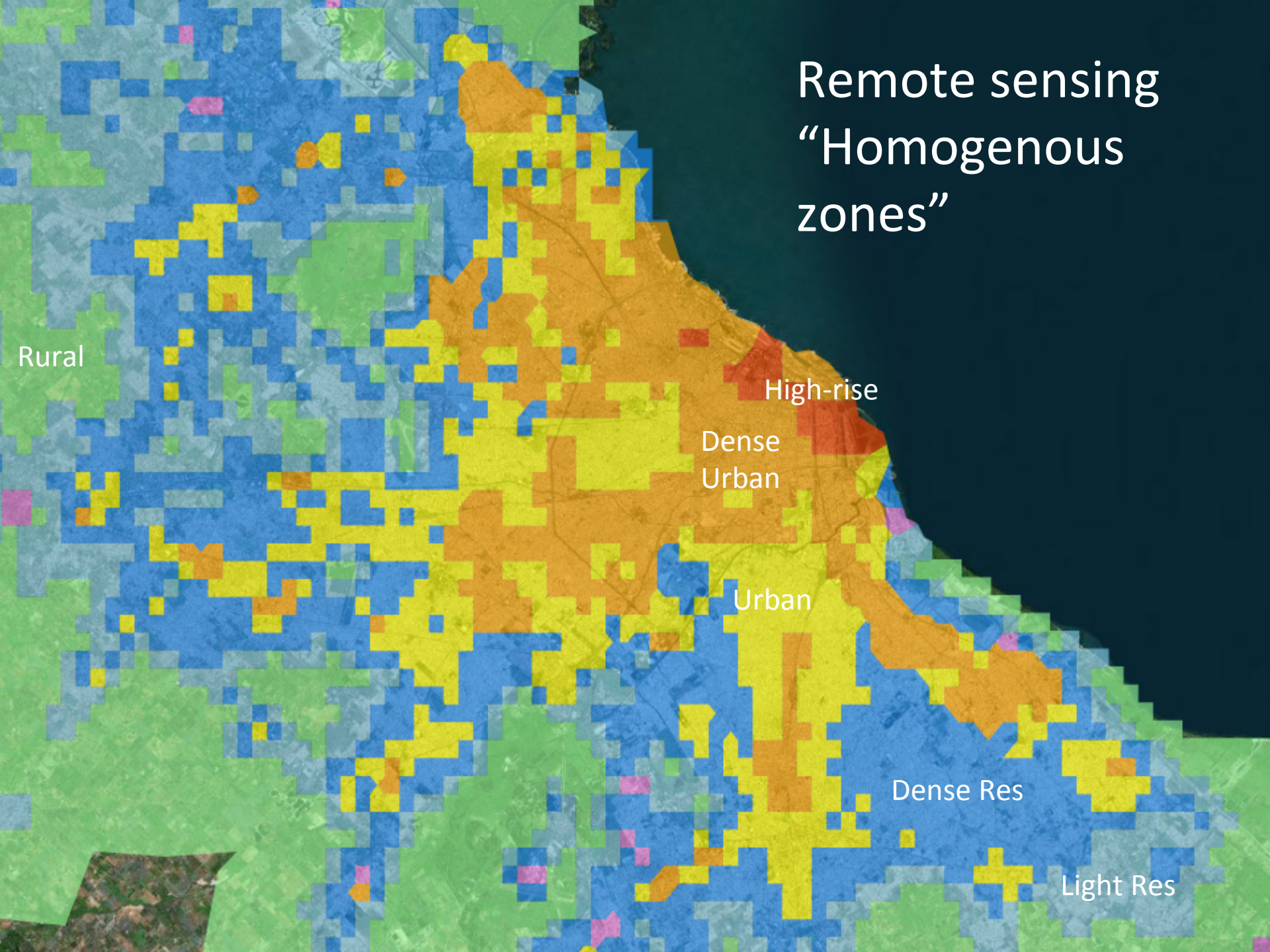
Outline

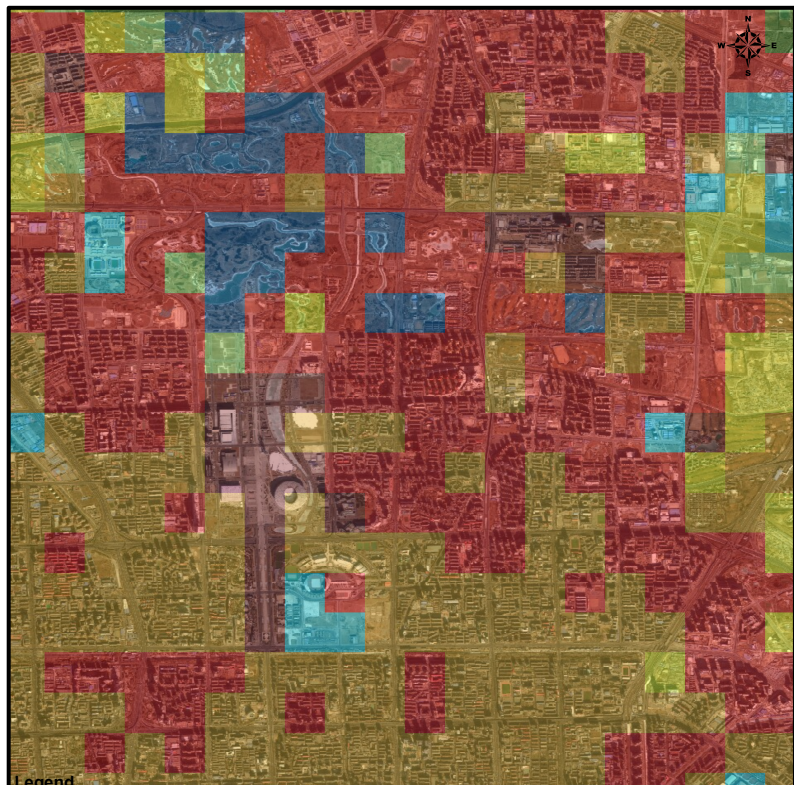
- Remote sensing classification
- Codes for damage assessment
- Characterization of buildings through mapping schemes
- Socioeconomic data

Data Sources

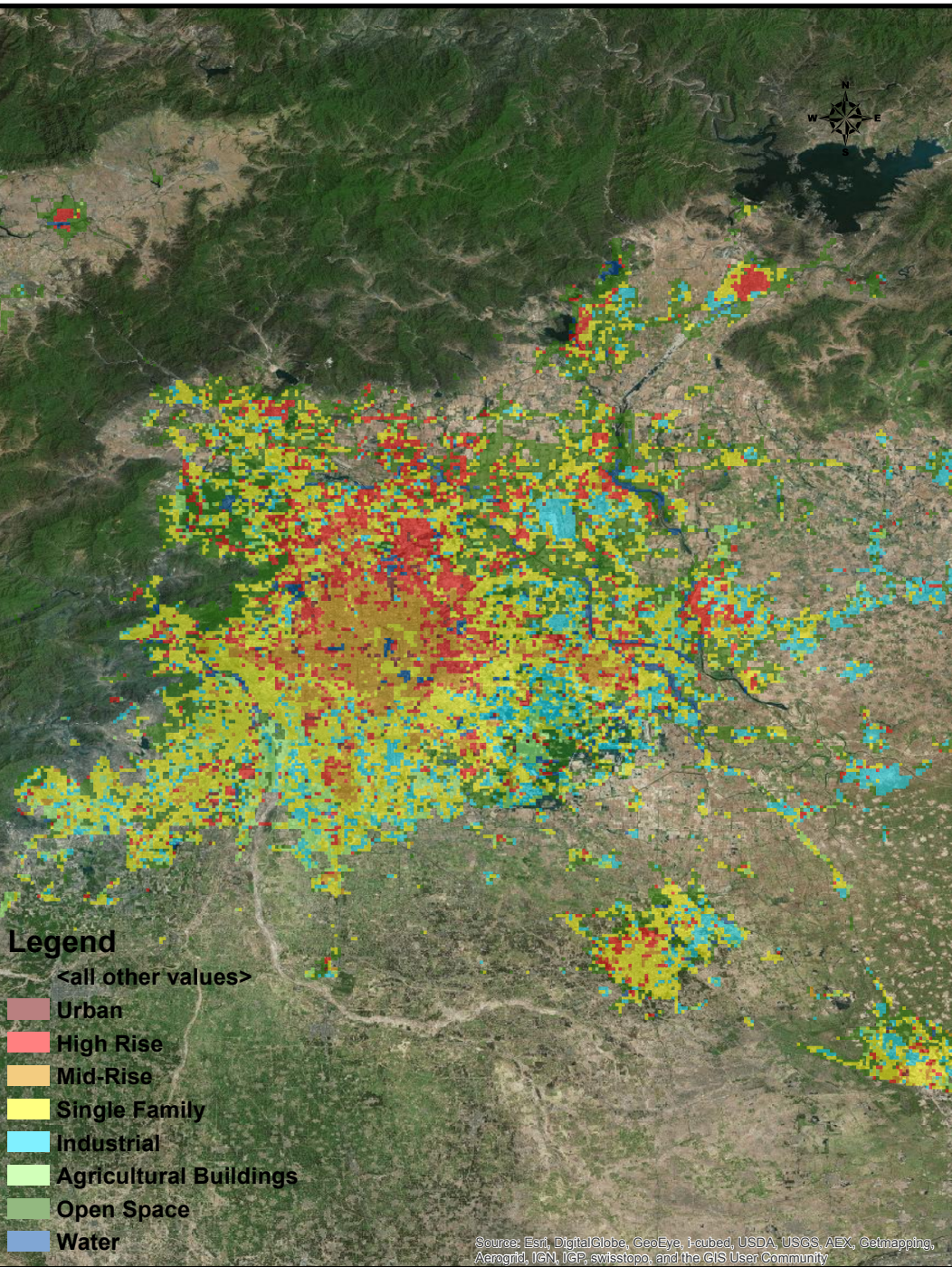
- Global Rural-Urban Mapping Project-Urban Extent: SEDAC
- Gridded Population of the World (GPW): SEDAC
- Landsat: Oak Ridge National Laboratory
- Global Impervious Surface Area (IMPSA): NOAA
- Visible Infrared Imaging Radiometer Suite (VIIRS): NOAA/NASA
- LandSat-8: USGS/NASA
- Global Human Settlement Layer (GHSL): JRC

Remote sensing “Homogenous zones”





Legend



Legend

<all other values>

- Urban
- High Rise
- Mid-Rise
- Single Family
- Industrial
- Agricultural Buildings
- Open Space
- Water

Sources: Esri, DigitalGlobe, GeoEye, Ikonos, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Mapping Schemes (Indonesia example)

Building Counts and Floor Area (Sq M) by Land Use, Number of Stories and Structural Type

Zone Land Use	Basic Structural Type	Detailed Structural Type	Stories	# of Buildings	Total Sq Meters
Airport	Reinforced Concrete	Frame	1	20	15,000
Commercial	Masonry	Confined masonry	1	861	173,413
Commercial	Masonry	Confined masonry	2	270	173,616
Commercial	Masonry	Reinforced masonry	1	175	37,352
Commercial	Masonry	Unreinforced clay brick	1	2151	303,389
Commercial	Masonry	Unreinforced clay brick	2	97	35,452
Commercial	Masonry	Unreinforced, with reinforced concrete floors	2	97	41,191
Commercial	Reinforced Concrete	Frame	1	451	105,211
Commercial	Reinforced Concrete	Frame	2	296	387,201
Commercial	Reinforced Concrete	Shear wall	1	77	12,214
Commercial	Reinforced Concrete	Shear wall	2	146	57,050
Commercial	Timber/Wood	Open frame at grade	1	886	118,346
Commercial	Other	Other		171	173,692
Industrial	Masonry	Confined masonry	1	849	171,021
Industrial	Masonry	Reinforced masonry	1	849	181,263
Industrial	Reinforced Concrete	Frame	2	562	735,185
Industrial	Steel	Braced frame	1	280	134,875
Industrial	Steel	Braced frame	7	1	8,784
Industrial	Steel	Light frame (transverse-frame; longitudinal-steel rod tension-only bracing)	1	562	762,777
Industrial	Steel	Moment frame	1	280	58,204
Industrial	Steel	Moment frame	2	280	48,667



Mapping schemes linked to homogenous zones

Spatial Inventory Data Developer

File Options Help

Data Input Mapping Scheme Modifiers Preview

Manage Mapping Schemes

Mapping Scheme

- RU - 100.0%
- RS - 100.0%
- VH - 100.0%
- IR - 100.0%
- HU - 100.0%
- AN - 100.0%
- HD - 100.0%
- UR - 100.0%
- CR - 52.0%
- LFINF - 50.0%
- HBET:1,3 - 67.0%
- LFM - Code: LFINF
Attribute: Lateral Load Resisting System
Description: Infilled frame
- MR - 45.0%
- S - 3.0%

Select zone: UR ☐ Include Modifiers

Building Distribution

Value	Percentage	Size	Cost
CR/LFINF/HBET:1,3	17.42	0.00	0.00
CR/LFINF/HBET:4,7	8.58	0.00	0.00
CR/LFM/HBET:1,3	11.70	0.00	0.00
CR/LFM/HBET:4,7	8.32	0.00	0.00
CR/LFM/HBET:8,999	5.98	0.00	0.00
MR	45.00	0.00	0.00
S	3.00	0.00	0.00

Total 100.0

Modifiers Build Exposure

GEM
GLOBAL EARTHQUAKE MODEL
working together to assess risk

Building Distribution

Mapping Scheme Library




Adjust modifiers

Spatial Inventory Data Developer

File Options Help

Data Input Mapping Scheme Modifiers Preview

Manage Modifiers

Zone **Building Type** **Value** **Percentage**

RU	MUR	CLBRS	50.00
		MON+STRUB	50.00
RS	MR	MUN99+RS	100.00
RS	MUR	CLBRS	50.00
		MON+STRUB	50.00
VH	CR	CIP	100.00
VH	CR/LFINF	ND	100.00
VH	CR/LFM	DU	100.00
VH	MR	MUN99+RS	100.00
VH	S	S99	100.00
IR	CR	CIP	100.00
IR	CR/LFINF	ND	100.00
IR	CR/LFM	DU	100.00
IR	MR	MUN99+RS	100.00
IR	S	S99	100.00
HU	CR	CIP	100.00
HU	CR/LFINF	ND	100.00
HU	CR/LFM	DU	100.00
HU	MR	MUN99+RS	100.00
HU	S	S99	100.00
HD	CR	CIP	100.00
HD	CR/LFINF	ND	100.00
HD	CR/LFM	DU	100.00
HD	MR	MUN99+RS	100.00
HD	MUR	CLBRS	50.00
		MON+STRUB	50.00
UR	CR	CIP	100.00
UR	CR/LFINF	ND	100.00
UR	CR/LFM	DU	100.00
UR	MR	MUN99+RS	100.00
UR	S	S99	100.00

Edit Modifier

Edit Building Distribution Modifier

Mapping Scheme

Mapping Scheme

- RU - 100.0%
- RS - 100.0%
- VH - 100.0%
- IR - 100.0%
- HU - 100.0%
- AN - 100.0%
- HD - 100.0%
- UR - 100.0%
- CR - 52.0%
 - LFINF - 50.0%
 - LFM - 50.0%
 - MR - 45.0%
 - S - 3.0%

Attribute

Lateral Load-Resisting System


Modifier Detail

Value	Percentage
DU	100.00

Total 100.0 %

OK Cancel

Build Exposure

 **GEM**
GLOBAL EARTHQUAKE MODEL
working together to assess risk

Results*

Spatial Inventory Data Developer

File Options Help

Data Input Mapping Scheme Modifiers Preview

Preview

Selected Layer Exposure

Export Exposure

Select location to save output:

C:/SIDD/nasa_argentina/argentina.csv

Select Export Data Format

CSV data(*.csv)

Feature Information

Detailed Information for Selected Feature

GID	LON	LAT	TAXONOMY	ZONE	NUM_BLDGS	AREA	REPCOST
-459673652	-58.45	-34.5624999942	CR+CIP/LFINF+DNO/HBET:1,3	VH	35.288379	0.0	0.0
-459673652	-58.45	-34.5624999942	CR+CIP/LFINF+DNO/HBET:4,7	VH	172.290321	0.0	0.0
-459673652	-58.45	-34.5624999942	CR+CIP/LFM+DUC/HBET:1,3	VH	193.048191	0.0	0.0
-459673652	-58.45	-34.5624999942	CR+CIP/LFM+DUC/HBET:4,7	VH	910.084329	0.0	0.0
-459673652	-58.45	-34.5624999942	CR+CIP/LFM+DUC/HBET:8,999	VH	1654.69878	0.0	0.0
-459673652	-58.45	-34.5624999942	MR+MUN99+RS/LWAL	VH	512.54	0.0	0.0
-459673652	-58.45	-34.5624999942	S+599	VH	183.05	0.0	0.0

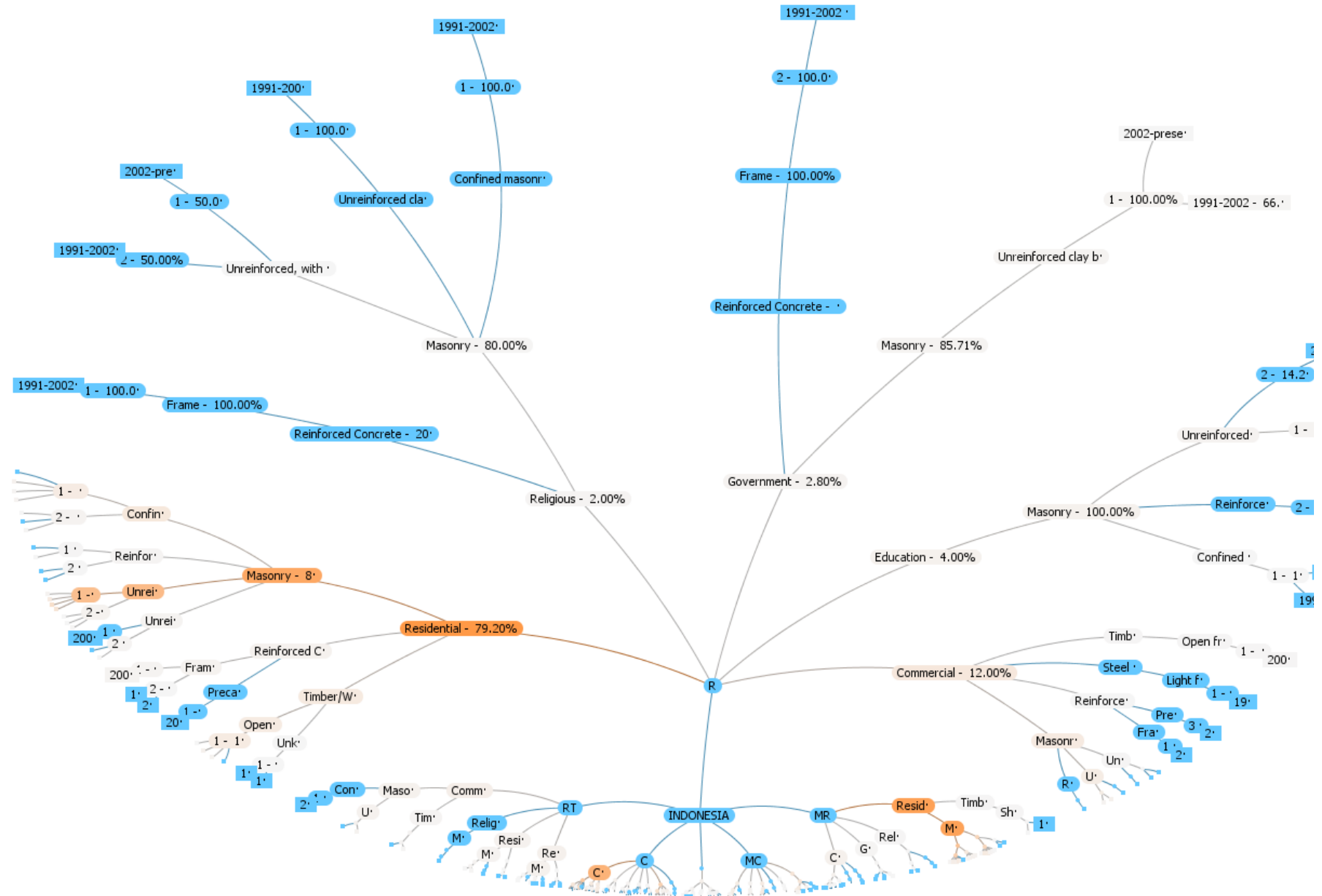
Exposure Exported

Building Count 3661

OK

* Adjust mapping schemes, observations, and zones as needed, repeat

Guarding against too many classes



Applied Technology Council (ATC) Codes

- Categories for modeling damage from earthquakes
- Developed in the U.S.
- Some overlaps in categories

- Permanent Dwelling (single family housing)
- Permanent Dwelling (multi-family housing)
- Temporary Lodging
- Group Institutional
- Housing Retail Trade
- Wholesale Trade
- Personal and Repair Services
- Professional, Technical and Business Services
- Health Care Service Entertainment and Recreation
- Parking Heavy Fabrication and Assembly
- Light Fabrication and Assembly
- Food and Drugs Processing
- Chemicals Processing
- Metal and Minerals Processing
- High Technology
- Construction
- Petroleum
- Agriculture
- Mining
- Religion and Nonprofit
- General Services
- Emergency Response Services
- Education
- Highway
- Railroad

- Air
- Sea/Water
- Electrical
- Water
- Sanitary Sewer
- Natural Gas
- Telephone & Telegraph
- Communication (Radio and TV)
- Flood Control
- General Commercial
- General Industrial
- Miscellaneous
- Multi-Family Dwelling- Homeowners Association
- Multi-Family Dwelling- Condominium Unit Owner
- Gasoline Service Station
- Restaurants
- Casinos
- Acute Care Services Hospitals
- Hotels - Large Hotels - Small and Medium
- Rental – General Commercial
- Colleges and Universities

Socioeconomic Data

- Used to weight mapping of ATC codes to land cover classes
- Using census data on employment in industry (by categories)
- Census categories are mapped to ATC codes (multiple apply in some cases)
- Work in progress!

L600	Table 6 Total employed population by industry and thrice industrial ratio by county (people, %)
L600001	Total Population of Age 16 and Over
L600002	Total Employed Population by Industry
L600003	Sub-Total Employed Population in Agricultural Industry
L600004	Sub-Total Employed Population in Mining Industry
L600005	Sub-Total Employed Population in Manufacturing Industry
L600006	Sub-Total Employed Population in Production and Supply of Electric Power, Gas and Water Industry
L600007	Sub-Total Employed Population in Construction Industry
L600008	Sub-Total Employed Population in Storage and Postal Industry
L600009	Sub-Total Employed Population in Transportation, Computer Services and Software Industry
L600010	Sub-Total Employed Population in Information Transfer, Wholesale and Retail Trade Industry
L600011	Sub-Total Employed Population in Hotel and Restaurants Industry
L600012	Sub-Total Employed Population in Financial Industry
L600013	Sub-Total Employed Population in Real Estate Industry
L600014	Sub-Total Employed Population in Leasing and Business Services Industry
L600015	Sub-Total Employed Population in Scientific Research and Polytechnic Services and Geological Prospecting Industry
L600016	Sub-Total Employed Population in Water Conservancy, Environment and Public Facilities Management Industry
L600017	Sub-Total Employed Population in Resident and Other Services Industry
L600018	Sub-Total Employed Population in Education Industry
L600019	Sub-Total Employed Population in Health Care, Social Security and Social Welfare
L600020	Sub-Total Employed Population in Culture, Sports and Entertainment Industry
L600021	Sub-Total Employed Population in Public Administration and Social Organizations
L600022	Sub-Total Employed Population in International Organizations
L600023	Percentage of Population in Primary Industry to Total Employed Population
L600024	Percentage of Population in Secondary Industry to Total Employed Population
L600025	Percentage of Population in Tertiary Industry to Total Employed Population

Mapping Census to ATC

ATC Occupancy Description

Retail Trade

Wholesale Trade

Personal and Repair Services

Professional, Technical and Business Services

Health Care Service

Entertainment and Recreation

Light Fabrication and Assembly

Construction

Agriculture

Mining

General Services

Education

Electrical

Restaurants

Census 2010 Industry Mapping

Information Transfer, Wholesale and Retail Trade

Storage and Postal

Resident and Other Services

Real Estate;

Transportation, Computer Services and Software;

Financial;

Leasing and Business Services;

International Organizations;

Scientific Research and Polytechnic Services and

Geological Prospecting

Health Care, Social Security and Social Welfare

Culture, Sports and Entertainment

Manufacturing

Construction

Agriculture

Mining

Water Conservancy, Environment and Public Facilities
Management;

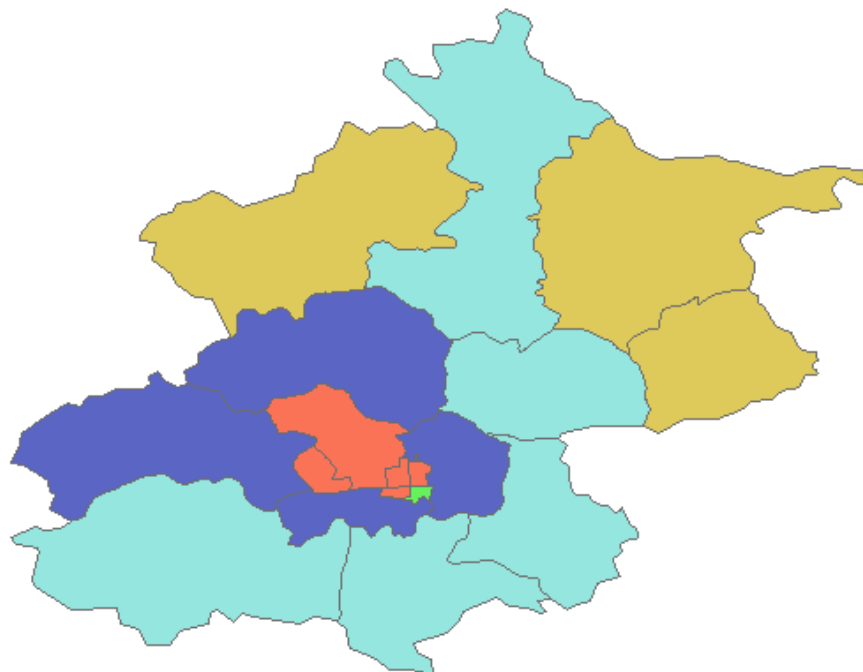
Public Administration and Social Organizations

Education

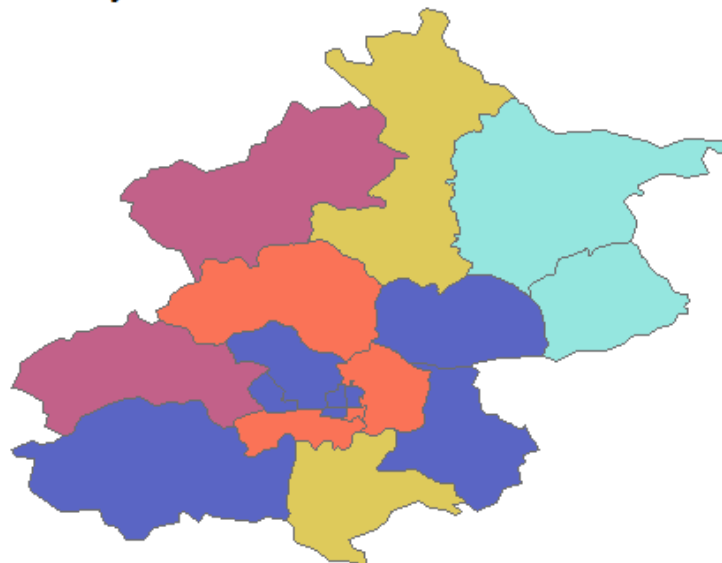
Production and Supply of Electric Power, Gas and Water

Hotels and Restaurants

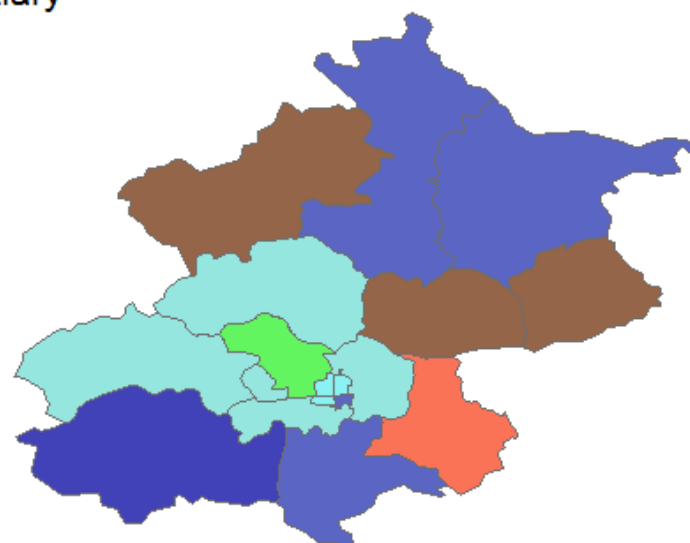
Primary



Secondary



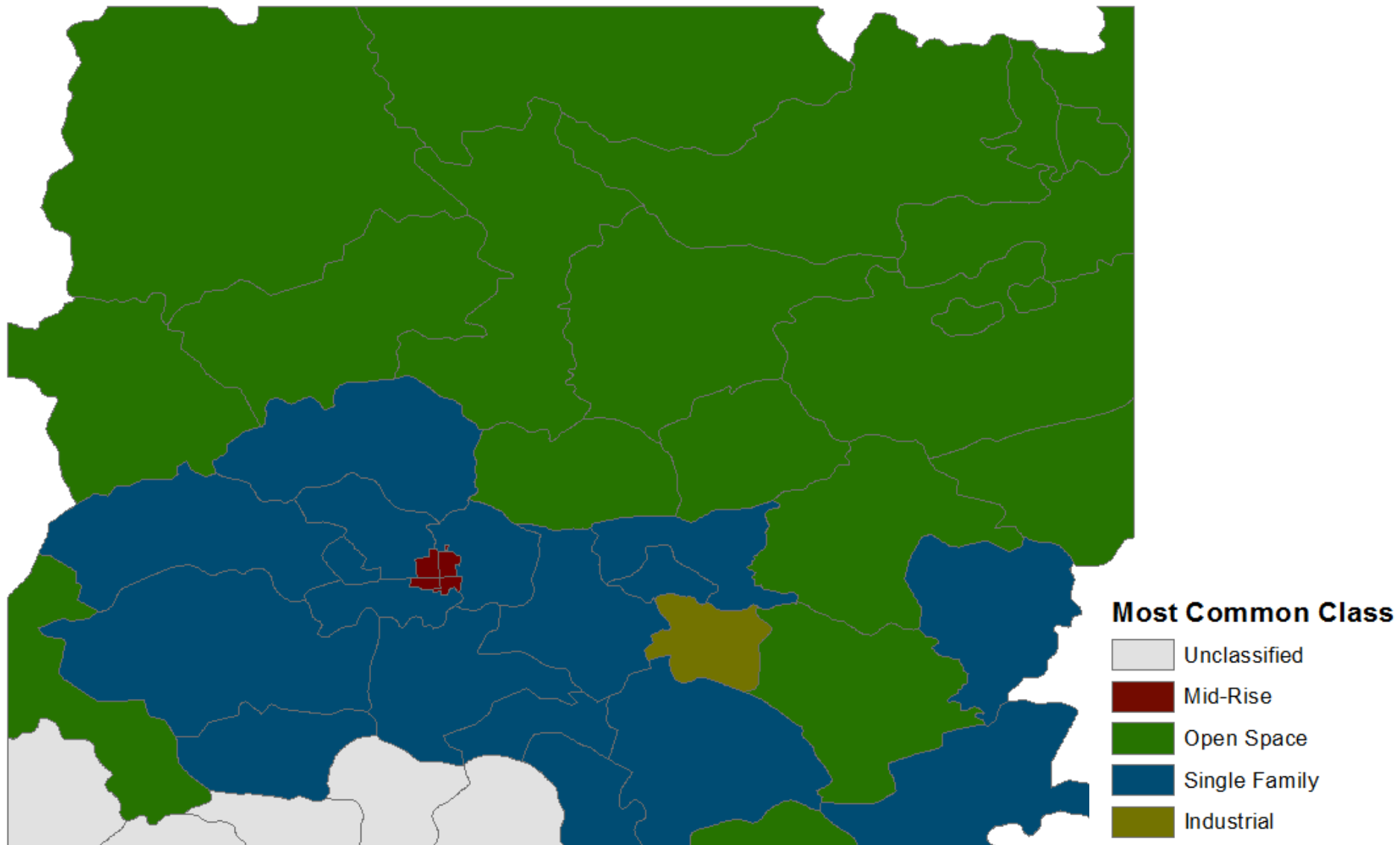
Tertiary



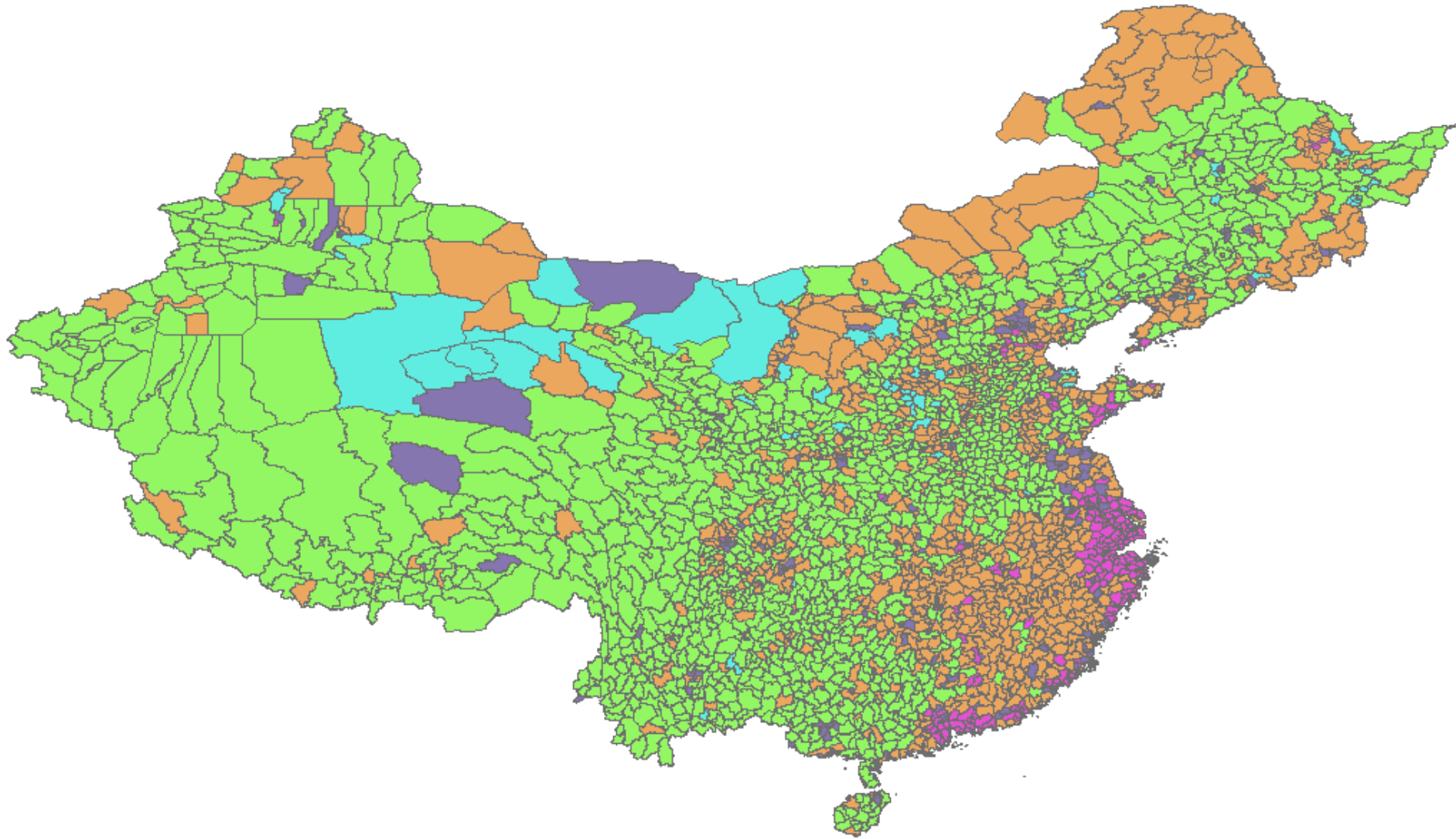
ATC Codes

- 5 Retail Trade
- 6 Wholesale Trade
- 7 Personal & Repair Services
- 8 Prof, Tech & Business
- 13 Light Fabrication & Assembly
- 18 Construction
- 20 Agriculture
- 23 General Services
- 25 Education
- 47 Restaurants

Land Cover By Census Unit



Clustering with K-Means



Remaining Work

- Round out mapping of Census data to ATC codes
 - Use demographic census where appropriate
- Complete validation
 - Merge k-means and other statistical groupings with land cover as sensitivity analysis
- Apply weights to land cover categories to produce estimates at the pixel level

Thanks!

Questions?

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