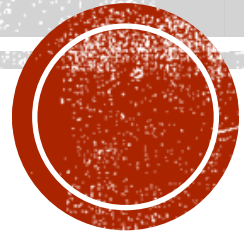
HIGH-RESOLUTION STATEWIDE SOCIO-DEMOGRAPHIC, LAND USE AND ECONOMIC DEVELOPMENT FRAMEWORK FOR TRANSPORTATION PLANNING – WEBINAR



NAVEEN ELURU

Professor

Civil, Environmental and Construction Engineering

University of Central Florida

Research Project

- Vision
- Methods
- Project Findings

Data products

- Demonstration
- Potential Use cases

BACKGROUND

Florida is a fast-growing state affecting transportation and mobility demand, and evolving land use patterns

The project is focused on developing a standardized high resolution state-wide sociodemographic, land use and economic development model (analogous to the FSUTMS framework)

A standardized model allows agencies to directly employ the standardized model or customize the model for local conditions reducing the need for agency resources

OBJECTIVES

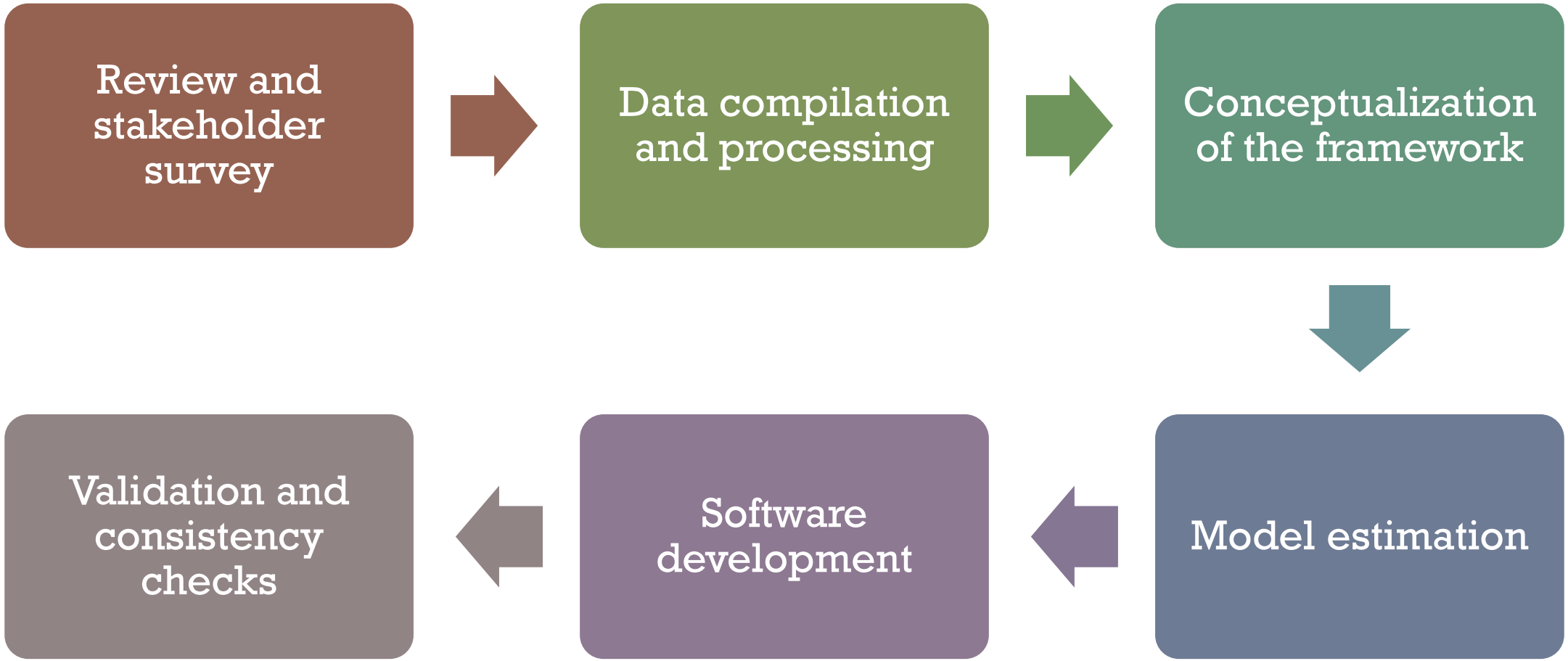
Establish a universal template of socio-demographic, land use and economic indicators

Develop and validate an algorithm to generate socio-demographic, land use and economic indicators for the future

Employ the validated algorithm developed to generate future socio-demographic, land use and economic indicators in 5-year increments from 2025 through 2050

Generate the variables for a spatial resolution that can be directly employed by local jurisdictions and statewide models

RESEARCH OVERVIEW



DATA PREPARATION

DATA PREPARATION

- We processed multiple year data - 2011-2020 - from various publicly available sources
- The research team considered publicly accessible data sources such as:
  - U.S. Census Bureau
  - American Community Survey
  - Bureau of Economic Analysis
  - Florida Department of Revenue
  - Federal Emergency Management Agency
  - FDOT Roadway Characteristics Inventory

DATA PREPARATION

- The research team has processed parcel data for all counties in FL
- The processed parcel data was employed to identify land use changes for each individual parcels
- We aggregated parcel level land use data at the block group level for generating land use distribution variables
- For other independent variables, we considered the following resolutions:
  - Block group
  - Census tract
  - County

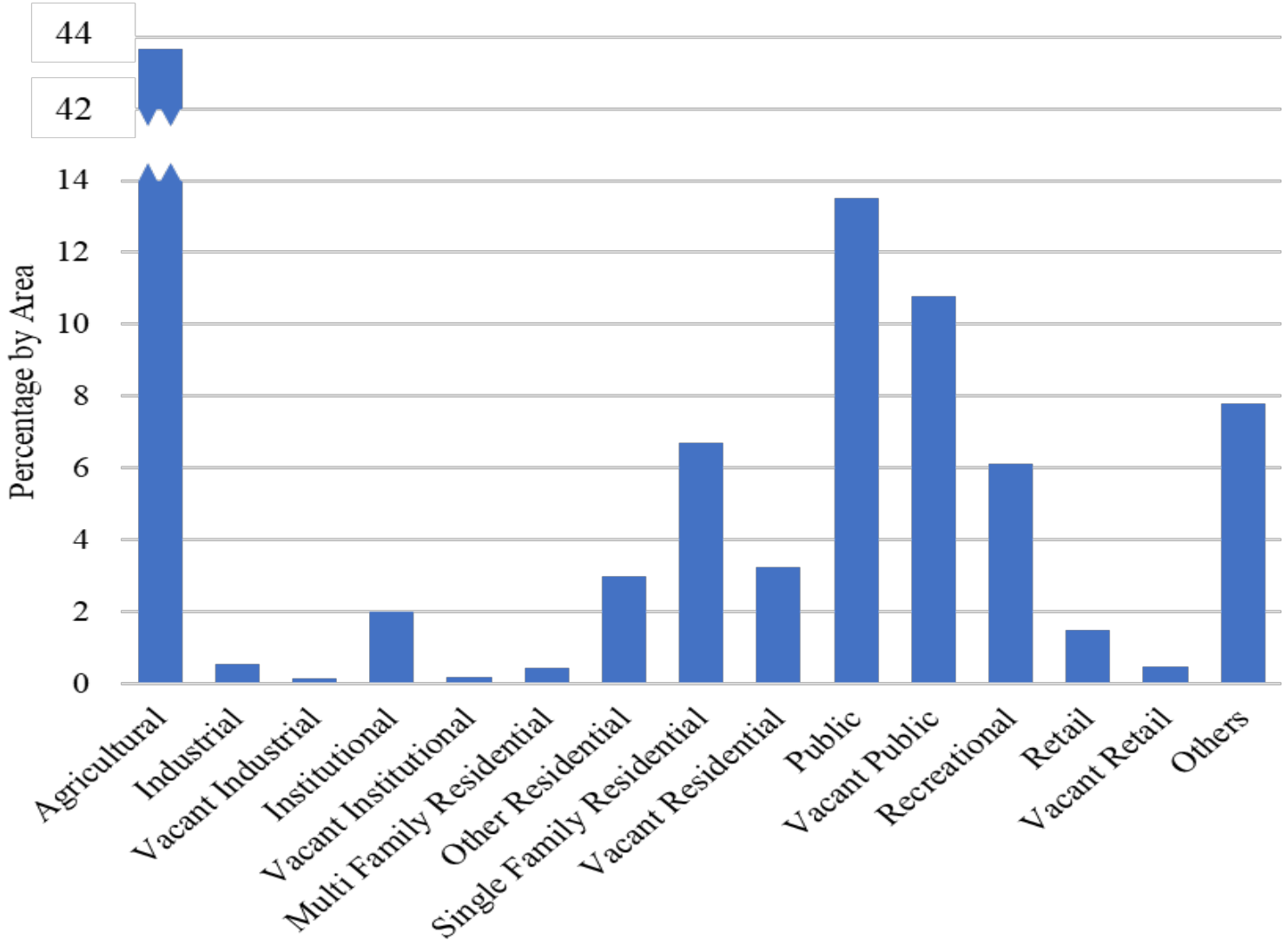
DATA SOURCES

Data Sources	Variables
U.S. Census Bureau and American Community Survey	Population, number of households, race distribution, vehicle ownership level, median income, number of business centers
Florida Department of Revenue	Land use type, land use change pattern at the parcel level, land use mix/land use diversity variable
FDOT Roadway Characteristics Inventory	Road density, sidewalk density, bike lane density, bus stop and bus route density
Bureau of Economic Analysis	Number of Jobs and Number of Jobs by Industry
Federal Emergency Management Agency	Flood Risk Level

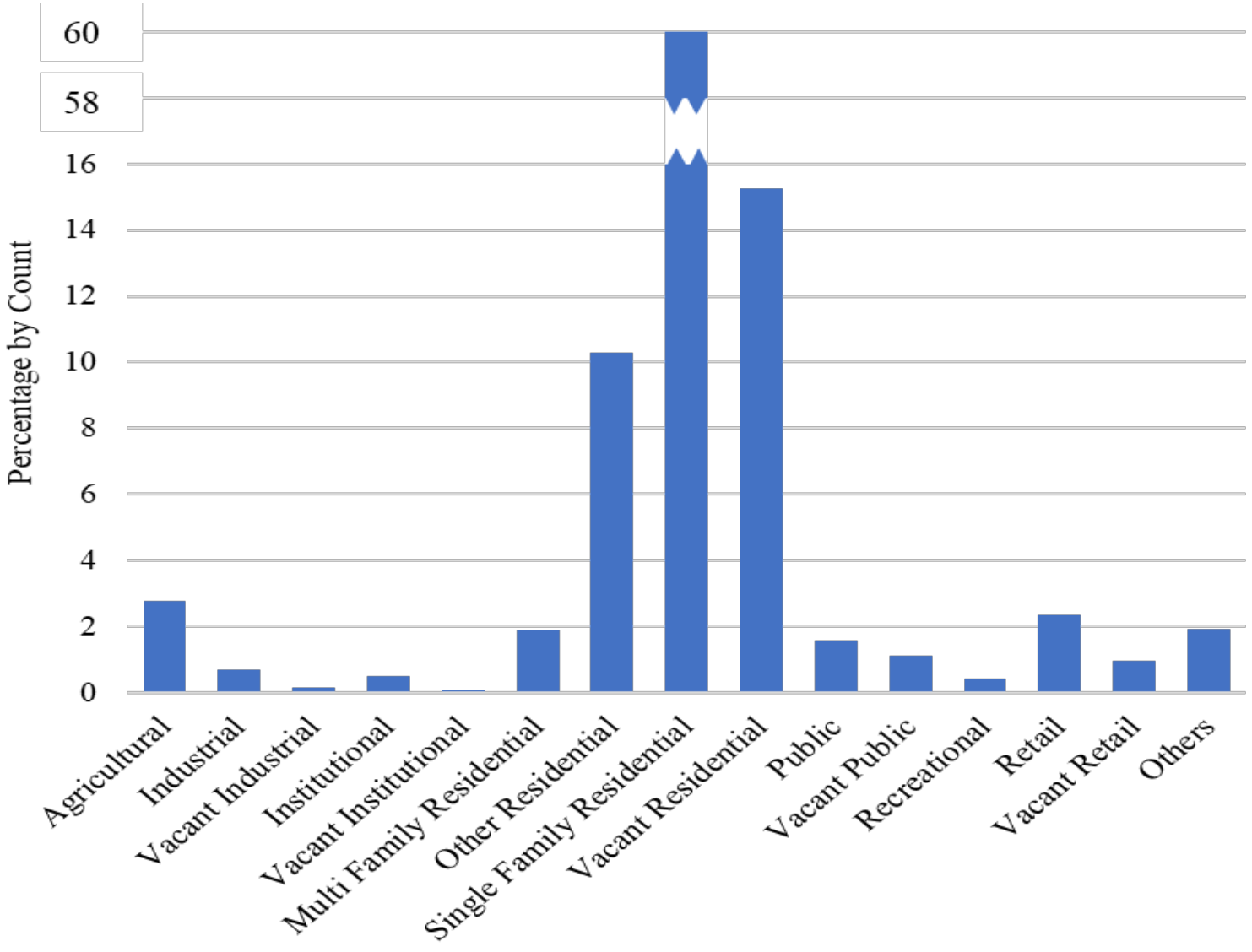
SPATIAL RESOLUTIONS

Spatial Resolutions	Variables
Parcel	Land use type and land use change pattern at the parcel level
Block Group	*Sociodemographic:* Population and race distribution *Land use:* Percentage of different land use types, land use mix/land use diversity variable
Census Tract	*Sociodemographic:* Number of households and vehicle ownership level *Economic development:* Median income
County	*Economic development:* Number of jobs, number of jobs by industry and number of business centers

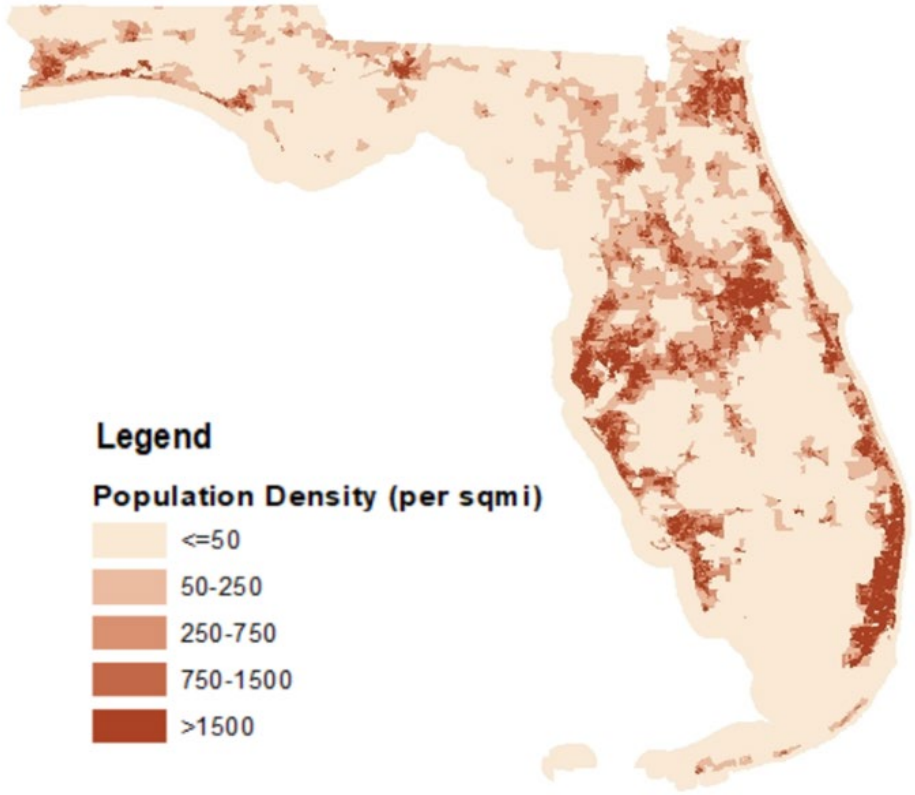
LAND USE DISTRIBUTION

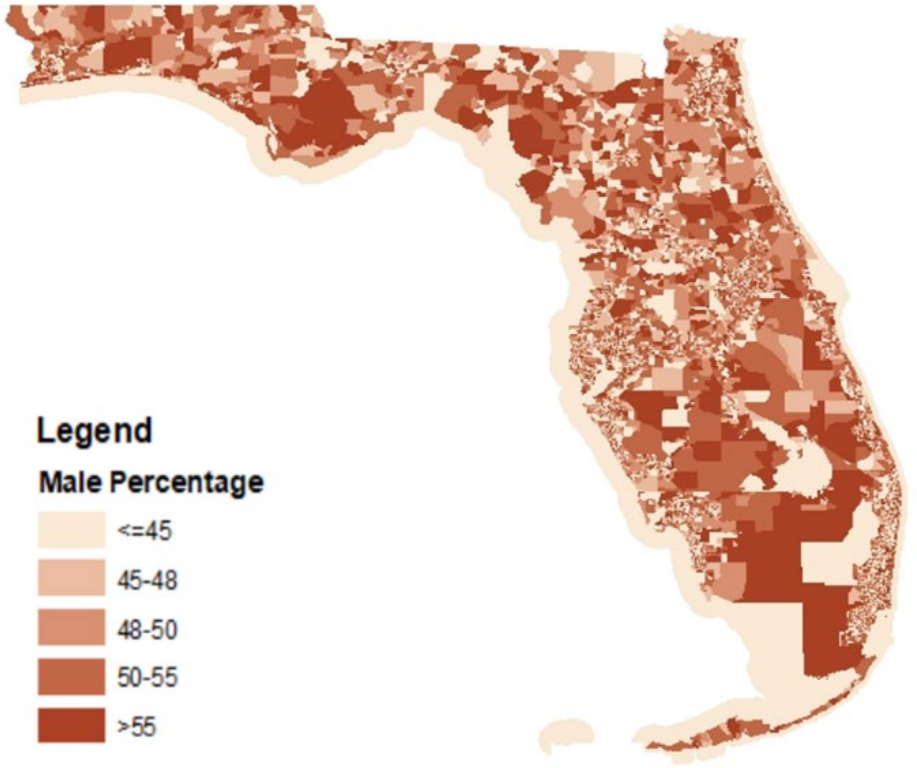


LAND USE DISTRIBUTION

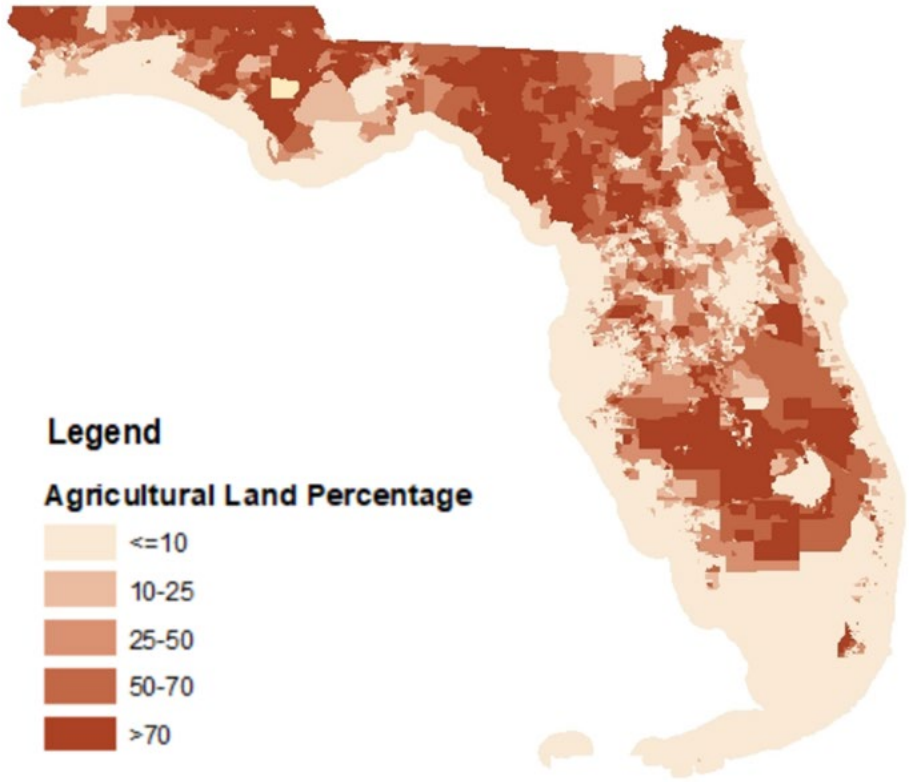


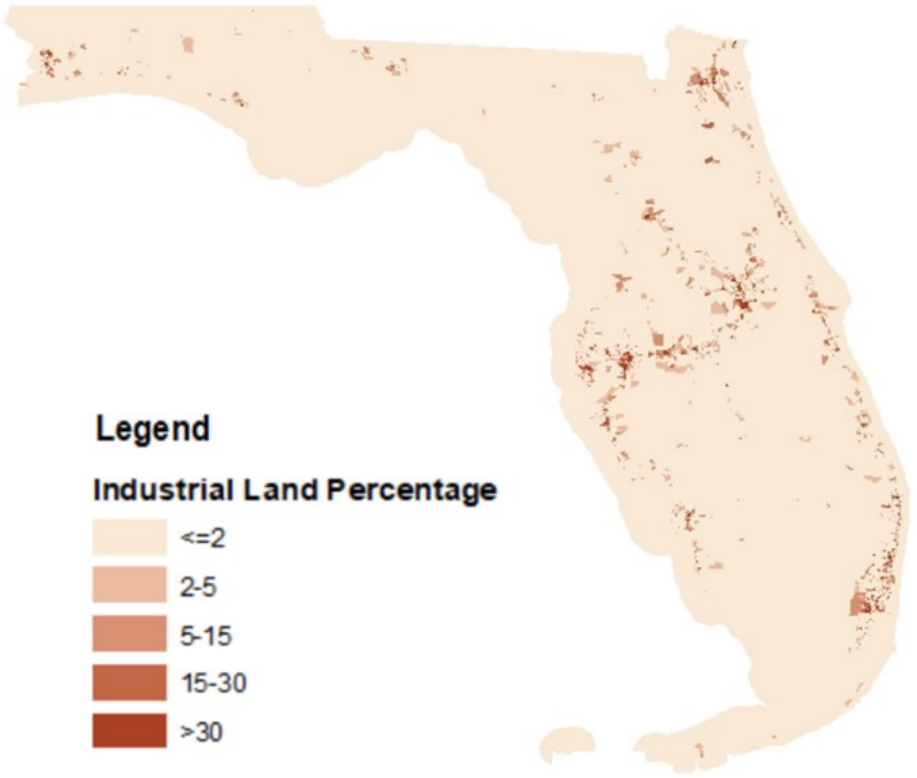
FINDINGS


Legend
Population Density (per sqmi)
<=50
50-250
250-750
750-1500
>1500

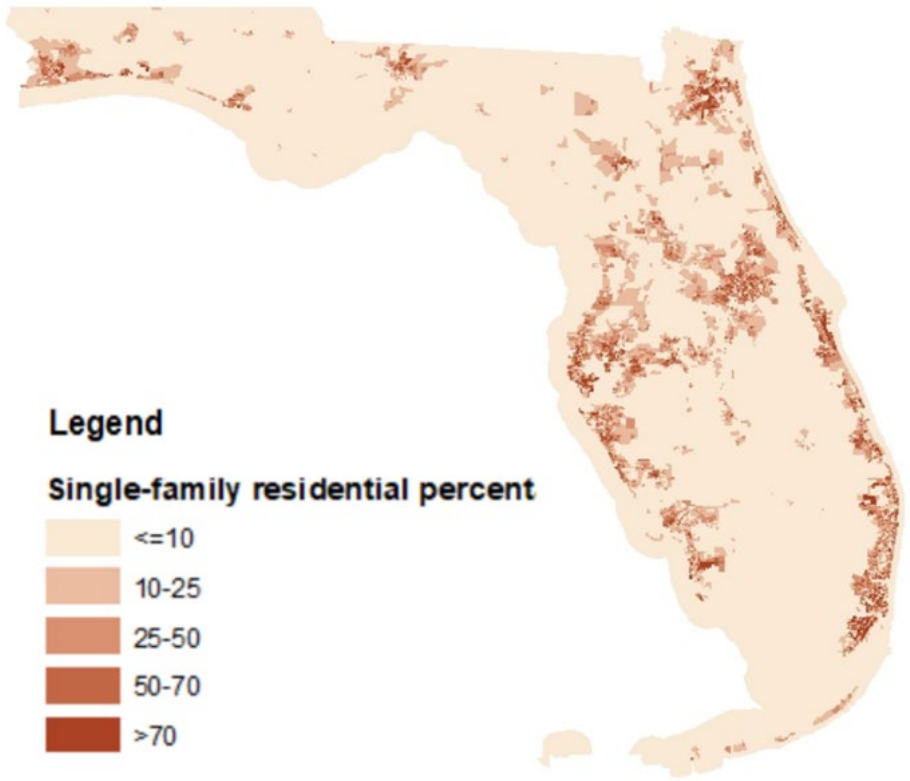

Legend
Male Percentage
<=45
45-48
48-50
50-55
>55

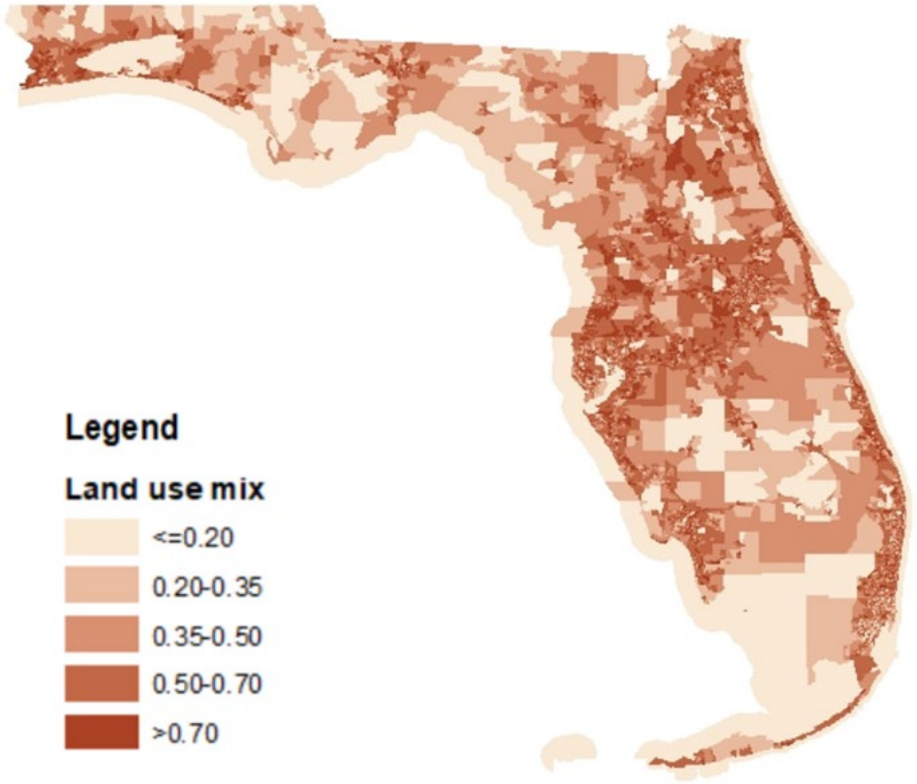
FINDINGS


Legend
Agricultural Land Percentage
<=10
10-25
25-50
50-70
>70


Legend
Industrial Land Percentage
<=2
2-5
5-15
15-30
>30

FINDINGS


Legend
Single-family residential percent
<=10
10-25
25-50
50-70
>70

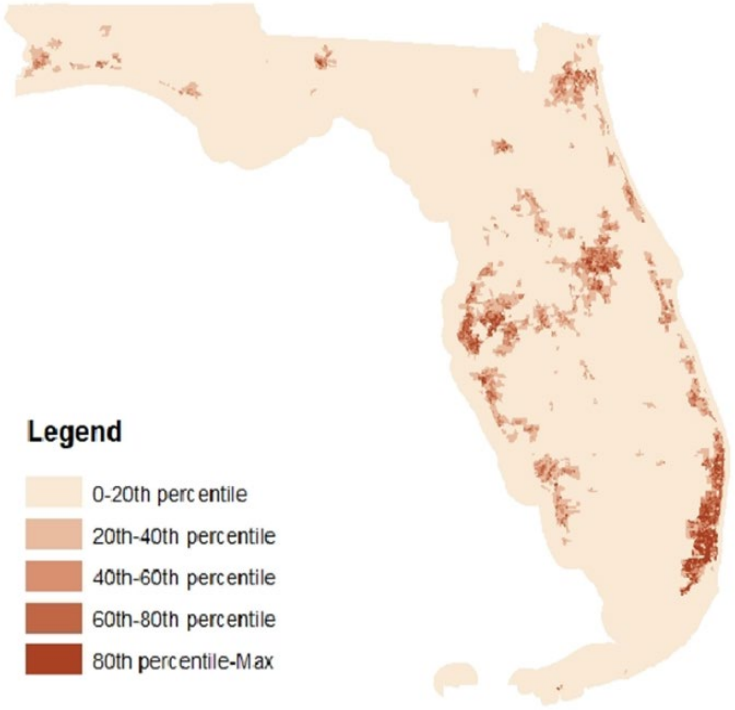

Legend
Land use mix
<=0.20
0.20-0.35
0.35-0.50
0.50-0.70
>0.70

DATA CONSISTENCY ANALYSIS

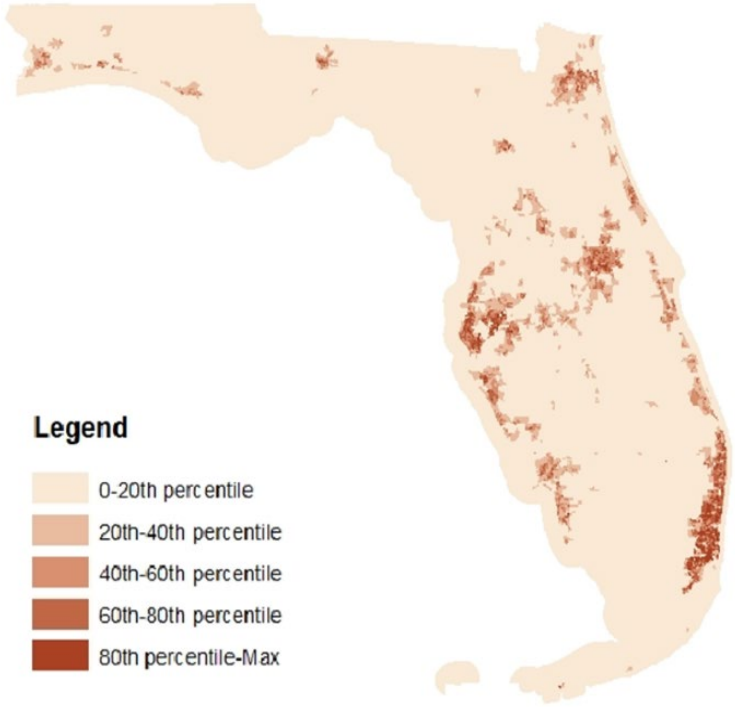
- After data preparation, we examine the consistency of the variables by comparing them at different spatial resolutions
- We undertook 3 comparisons analyses:
  - CT level – Population, HH and Residential Parcel Density
  - County Level – Population and Job Density
  - County Level – Agricultural Area and Agricultural Products

Variables	Total Count (in million)	Per Household (Total HH = 7.93M)
Population	21.22	2.68
Number of Jobs	6.62	0.83
Number of Residential Parcels (Single-family, Multi-family and Other Residential)	6.54	0.82

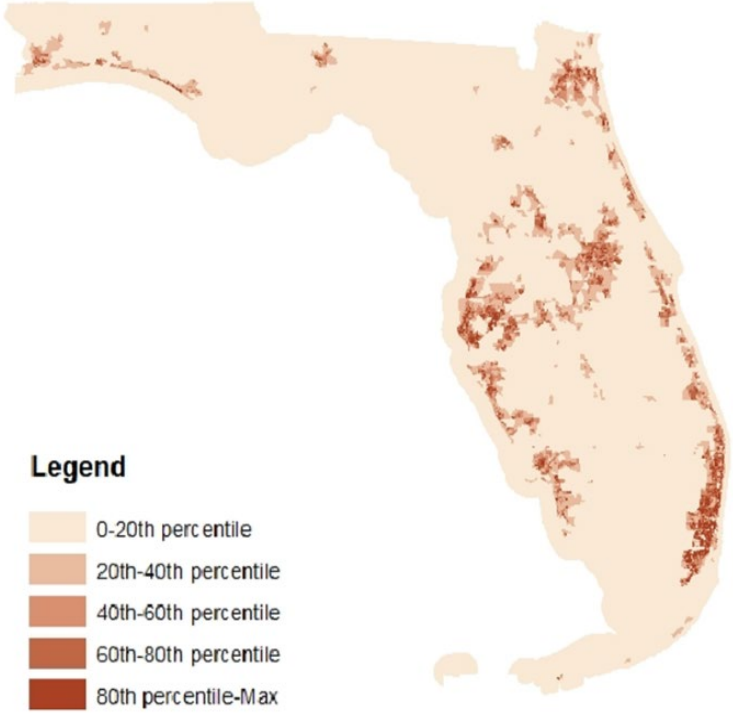
DATA CONSISTENCY



CT – Population Density



CT – HH Density

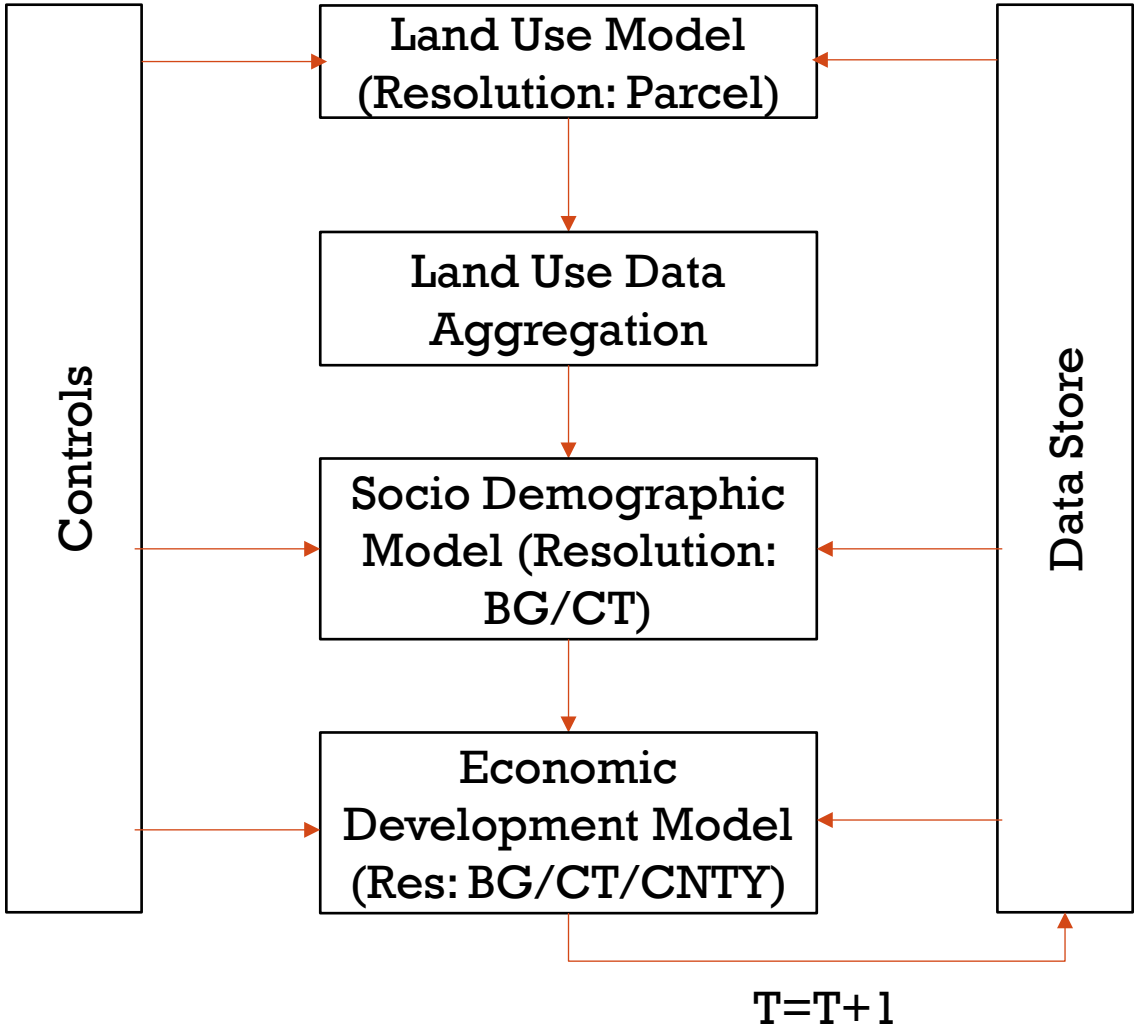


CT – Residential Parcel Density

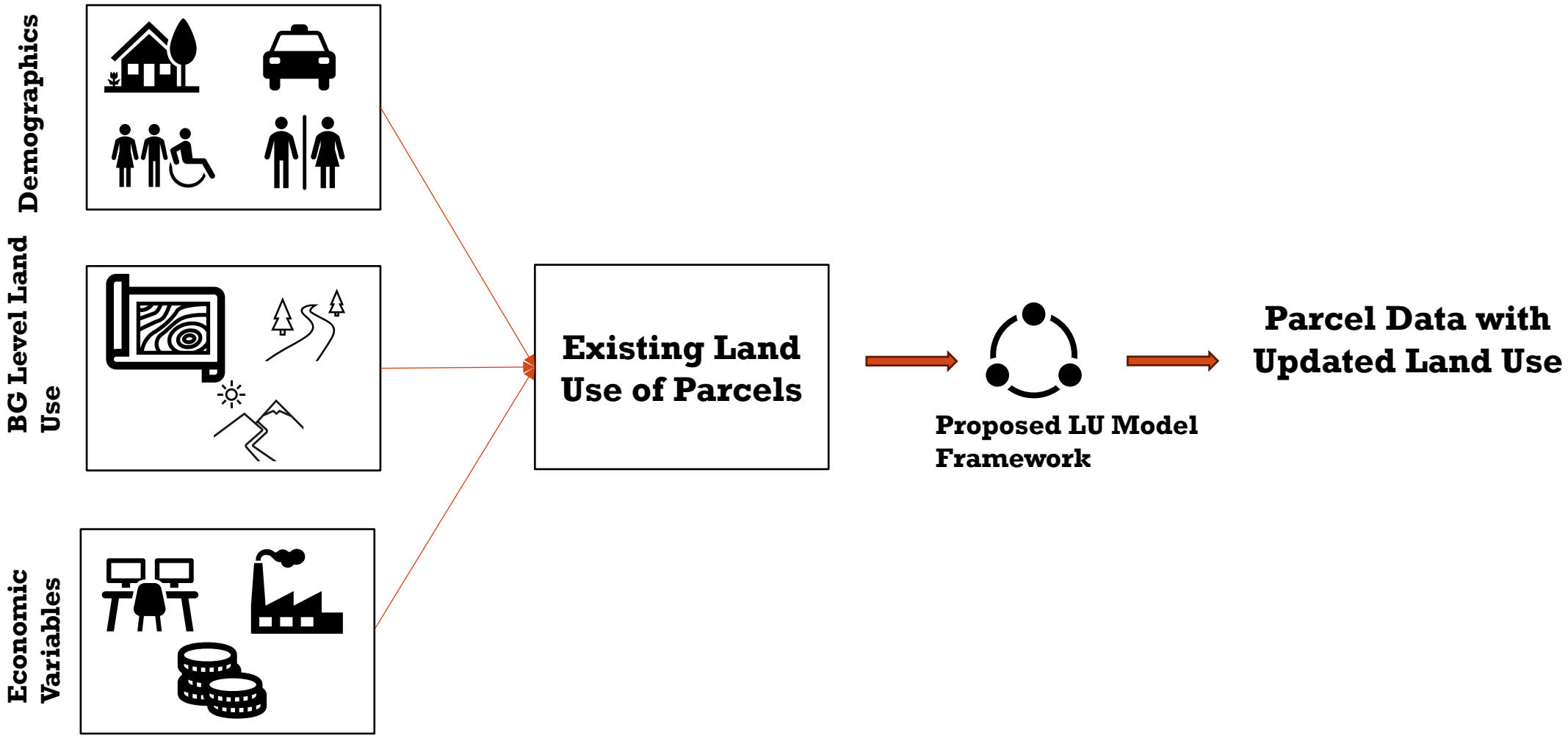
18

CONCEPTUAL FRAMEWORK FOR LAND USE EVOLUTION

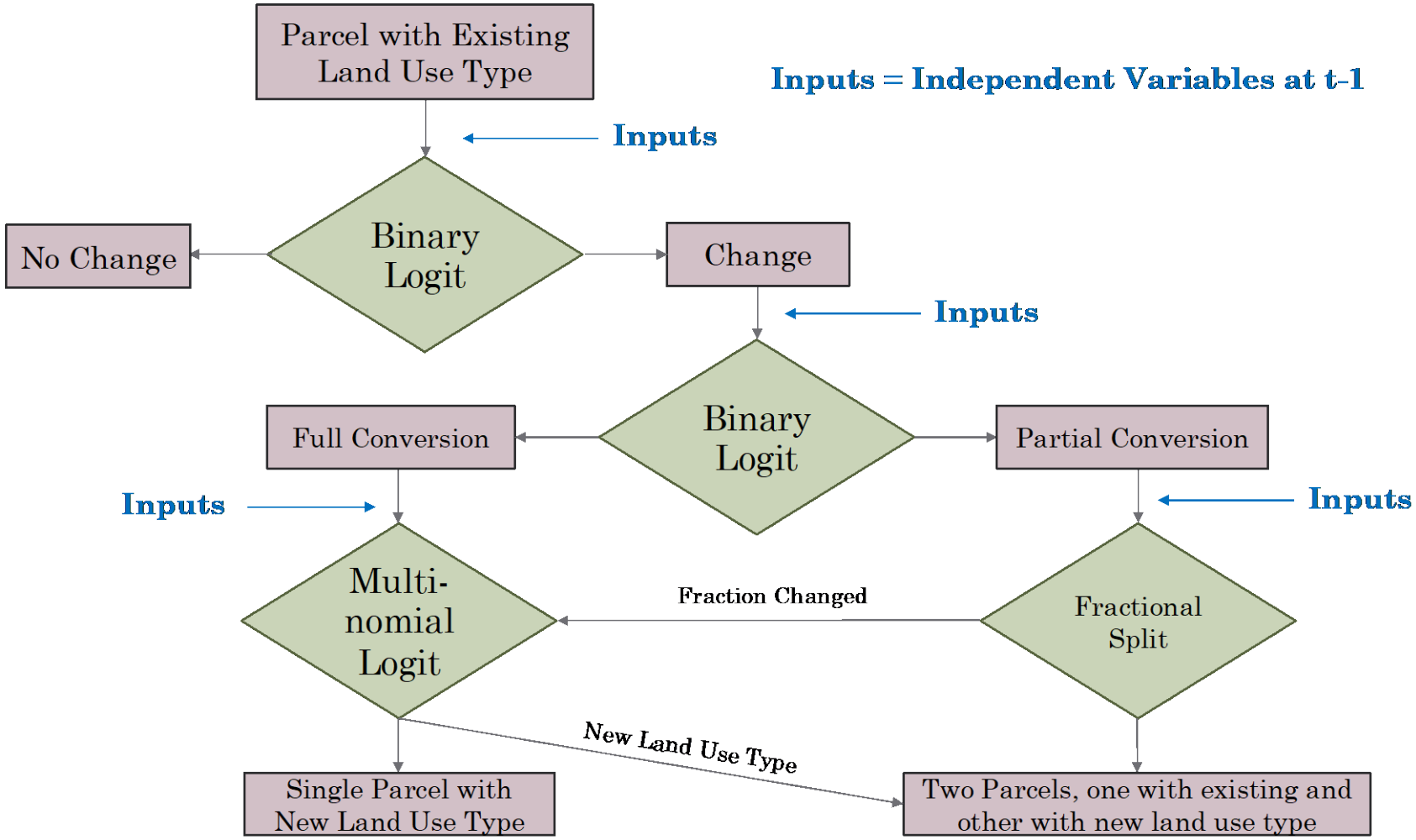
MODEL FRAMEWORK



MODEL FRAMEWORK



LAND USE MODEL STRUCTURE



SOCIO-DEMOGRAPHIC VARIABLES

- Population
- No. of HHs
- Vehicle Ownership
- Ethnicity Distribution

ECONOMIC DEVELOPMENT VARIABLES

- No. of Jobs
- Jobs by industry
- No. of Businesses
- Median Income

SOCIO-DEMOGRAPHIC VARIABLES

Socio-demographics	Dependent Variable	Resolution	Forecasting Method	Independent Variables
Population	Population Change	Block Group	Linear Regression	Demographics, economic factors at year t and land use change between t and t-1
No of HHs	No of HHs	Census Tract	Conversion Factor	Population at year t
Vehicle ownership	Fraction of Ownership Level	Census Tract	MNL Fractional Split	Demographic and economic factors at year t-1
Race Distribution	Population by Race	Block Group	MNL Fractional Split	Demographic and economic factors at year t-1

ECONOMIC DEVELOPMENT VARIABLES

Economic Development	Dependent Variable	Resolution	Method	Independent Variables
No of Jobs	Jobs in thousand	County	Linear Regression	Sociodemographic and land use at year t-1
No of jobs by industry	Fraction of jobs	County	MNL based Fractional Split	Land use at year t-1
No of Businesses	Number of businesses	County	Conversion Factor	Number of jobs
Median Income	Median income in thousand	Census Tract	Linear Regression	Sociodemographic, land use and economic development at year t-1

SAMPLE MODEL SYSTEM: SINGLE FAMILY RESIDENTIAL

CHANGE VS. NO CHANGE MODEL

- Model: Binary Logit (Base: No Change)

Variable	Estimate	t stat
Intercept	-3.300	-46.29
BG level Race Distribution (Base: % Other Race groups)		
% Hispanic	-0.015	-8.528
CT level vehicle ownership (Base: % HHs with vehicles)		
% Zero Vehicle HHs	0.021	4.852
Job density	0.205	3.634
Ln(Area in Acre)	-0.435	-15.306
BG level Land Use (% by area) (Base: Other LUs)		
% Single Family Residential	-0.02	-14.962
% Multi-Family Residential	0.012	2.837
% Flood Zone A	0.007	2.817

FULL VS. PARTIAL CONVERSION

- Model: Binary Logit (Base: Partial Conversion)

Variable	Estimate	t statistic
Intercept	-0.654	-5.091
Pop density (per acre)	-0.076	-5.784
Block Group Level Race Distribution (Base: % White, Black American and Other Race)		
% Hispanic	0.015	7.760
% Asian	-0.066	-5.766
CT level vehicle ownership (Base: % Households with vehicles)		
% Zero Vehicle HHs	0.026	5.891
Job density (per acre)	-0.695	-9.110
Block Group Level Land Use (% by area) (Base: Other Land Use Categories)		
Single Family Residential	0.007	4.293
Mixed Use	0.156	5.593
Commercial	-0.014	-3.327
Vacant Land Use	-0.004	-2.196
Land Use Mix/ Land Use Diversity	-2.006	-9.742

PROPORTION OF AREA CHANGED

- Model: MNL based Fractional Split (Base: % No Change)

Variable	Estimate	t statistic
Intercept	-1.248	-27.363
Population density	-0.014	-2.484
Block Group Level Race Distribution (Base: % White and Hispanic)		
% Black American	-0.005	-5.059
% Asian	-0.008	-1.945
% Other Race	0.015	2.427
Job density	-0.371	-9.129
Block Group Level Land Use (% by area) (Base: Other Land Use Categories)		
% Single Family Residential	-0.004	-4.397
% Mixed Use	0.054	3.521
% Commercial	-0.013	-7.080
% Vacant Land Use	-0.007	-6.258

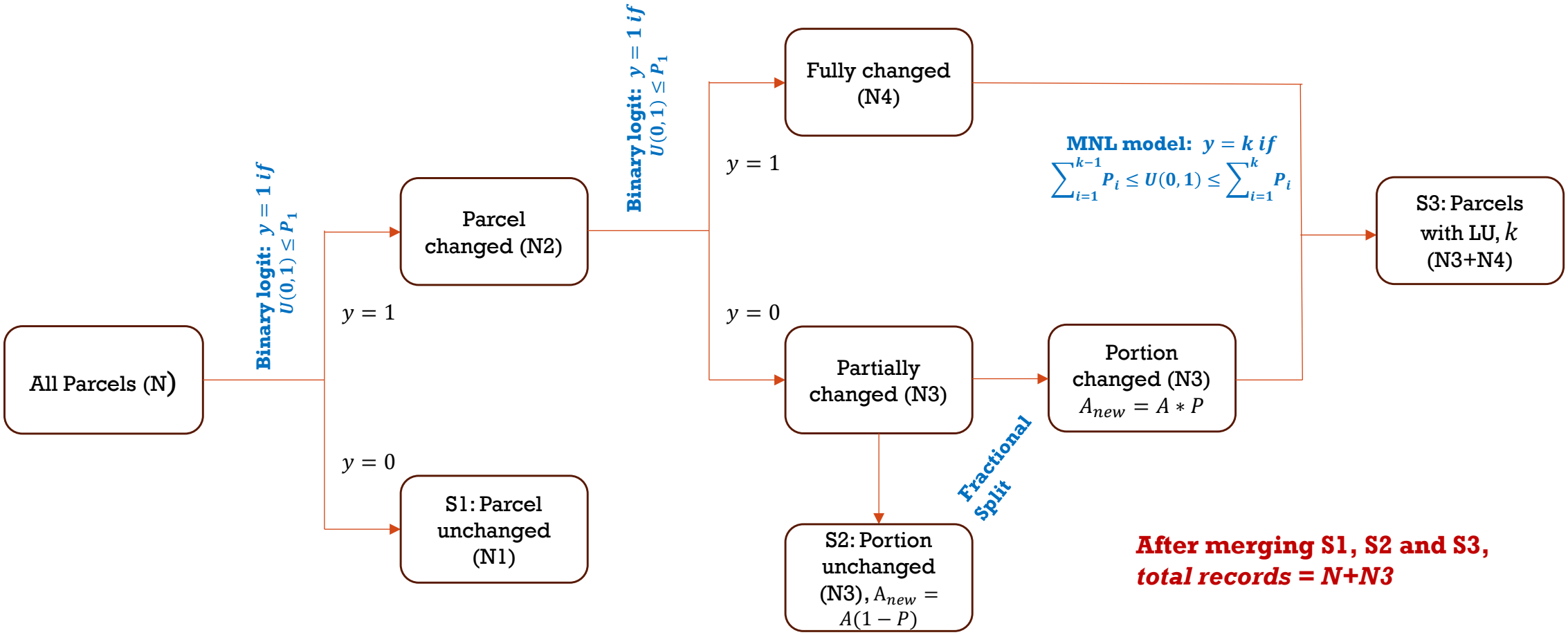
NEW LAND USE TYPE

- Model: Multinomial Logit Model (Base: Other Residential)

Variables	Vacant Residential		Others		MF Residential		Recreational		Public		Agricultural		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Intercept	1.218	5.272	-0.299	-1.111	-2.824	-7.494	-1.173	-3.494	-1.982	-3.770	3.818	12.238	-1.137	-5.397
Pop density (per acre)	-0.100	-9.138	-0.067	-4.317	--	--	--	--	-0.064	-2.683	-0.978	-11.294	-0.100	-8.492
Block Group Level Race Distribution (Base: % White)														
% Hispanic	0.003	1.737	0.006	3.249	0.011	5.724	--	--	0.014	3.414	-0.011	-3.772	--	--
% Black American	0.011	5.174	--	--	--	--	-0.029	-5.188	0.016	3.370	--	--	0.008	4.460
% Asian	-0.106	-10.839	-0.020	-2.083	-0.122	-7.501	-0.062	-3.797	--	--	-0.060	-3.092	-0.058	-5.913
% Other Race	-0.017	-1.746	-0.050	-3.401	--	--	--	--	-0.089	-3.613	--	--	-0.040	-3.160
Census Tract Level Vehicle Ownership (Base: % Households with vehicles)														
% Zero Vehicle HHs	0.088	15.168	--	--	0.127	17.016	0.051	3.796	0.069	5.924	--	--	0.074	11.217
Median Income	--	--	0.006	3.243	-0.010	-3.523	0.005	1.811	-0.011	-3.090	-0.013	-3.778	--	--
Job density (per acre)	-0.653	-10.394	-0.634	-7.640	--	--	-1.519	-11.779	-1.468	-10.488	--	--	--	--
Block Group Level Land Use (% by area) (Base: Other Land Use Categories)														
% Single Family	0.025	14.453	0.010	4.408	0.041	15.511	0.012	4.035	0.030	8.972	0.014	3.073	0.030	13.792
% Vacant Land Use	0.021	11.440	-0.012	-4.222	--	--	-0.036	-6.208	-0.027	-4.510	-0.013	-3.450	--	--
Land Use Mix	-1.738	-8.024	0.865	3.159	0.823	2.104	2.474	6.120	1.814	4.281	-2.980	-7.814	1.217	4.172

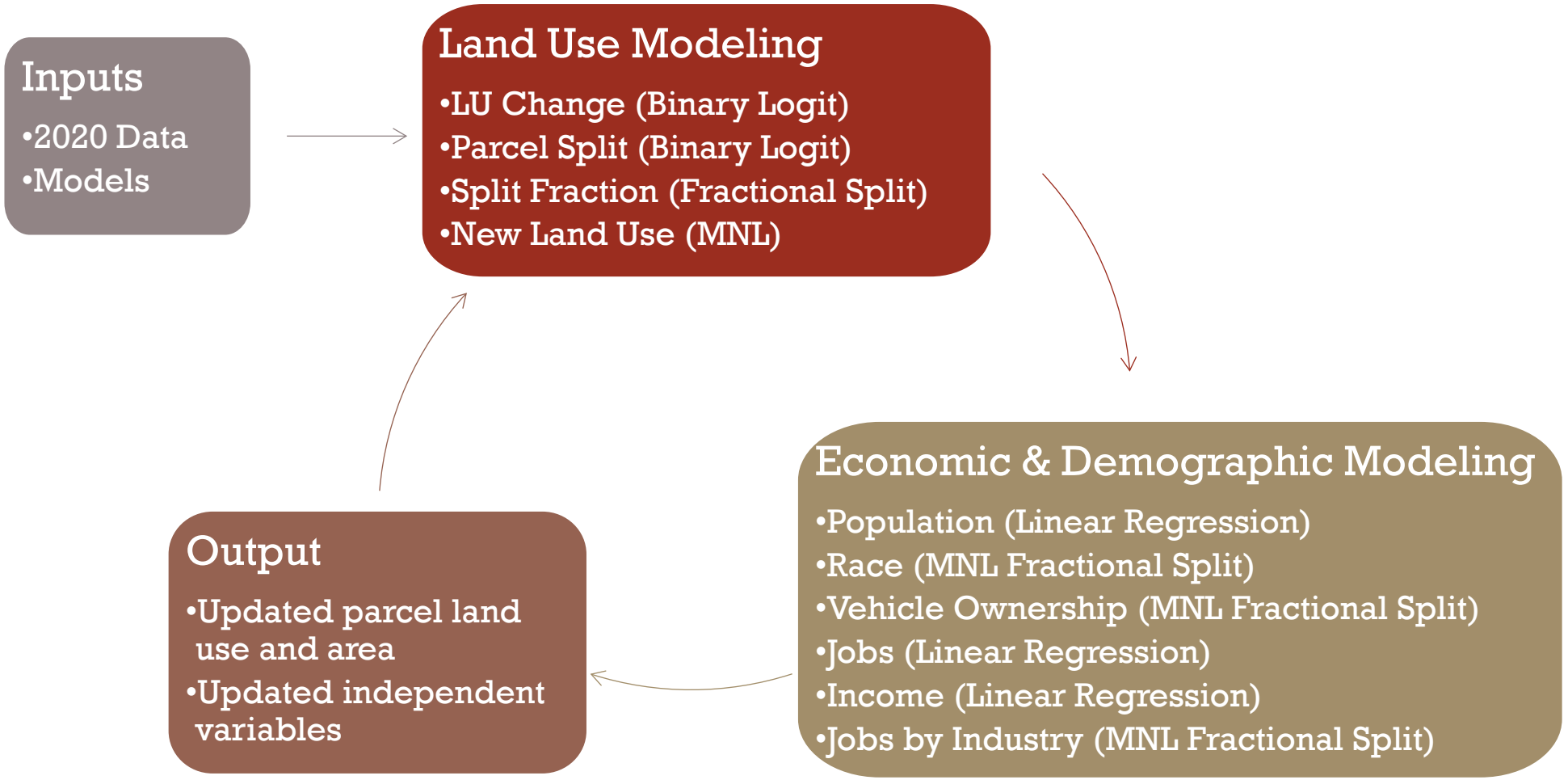
SIMULATION ENGINE

PREDICTION FRAMEWORK

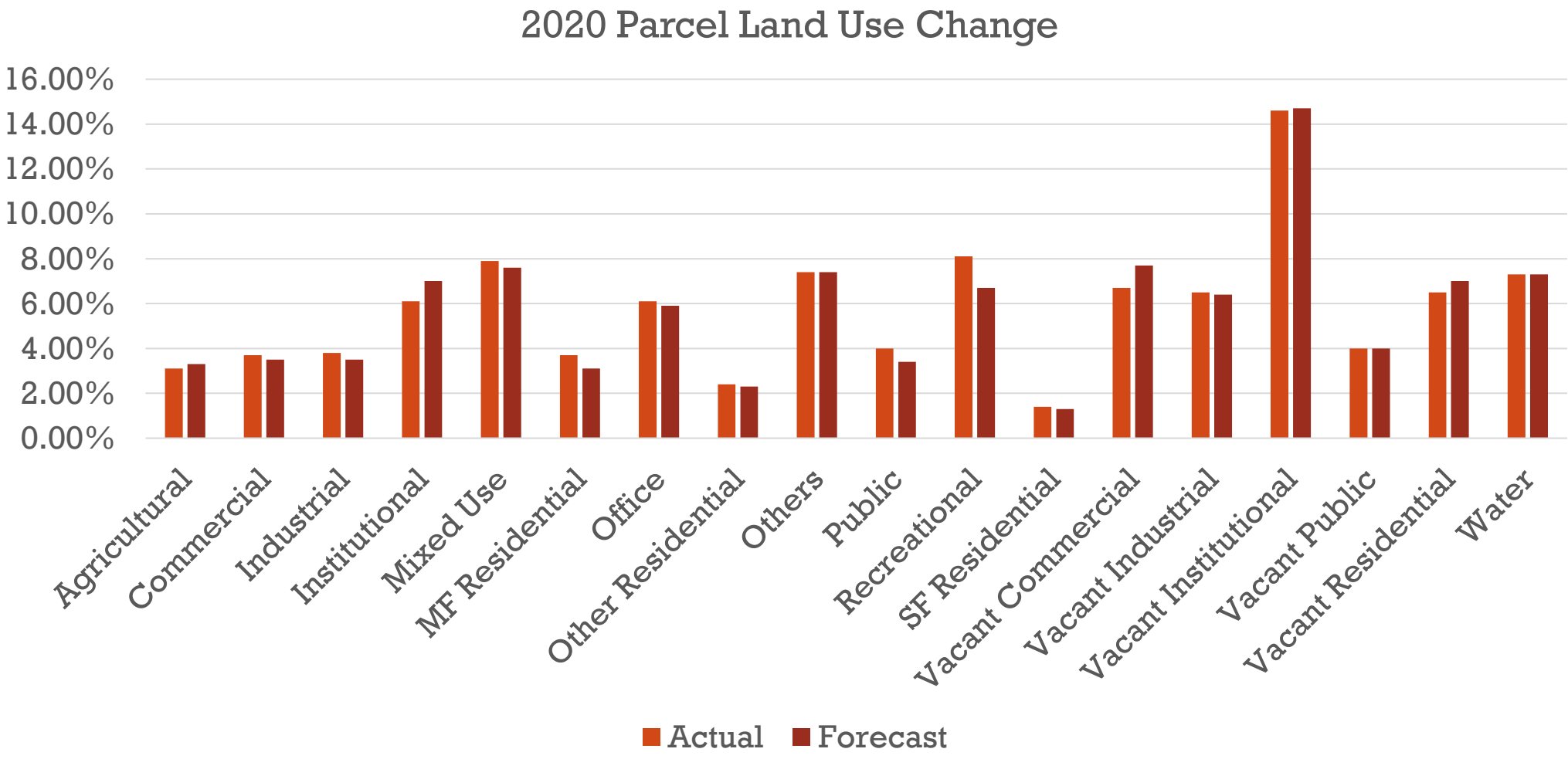


After merging S1, S2 and S3, *total records = N+N3*

SIMULATION ENGINE

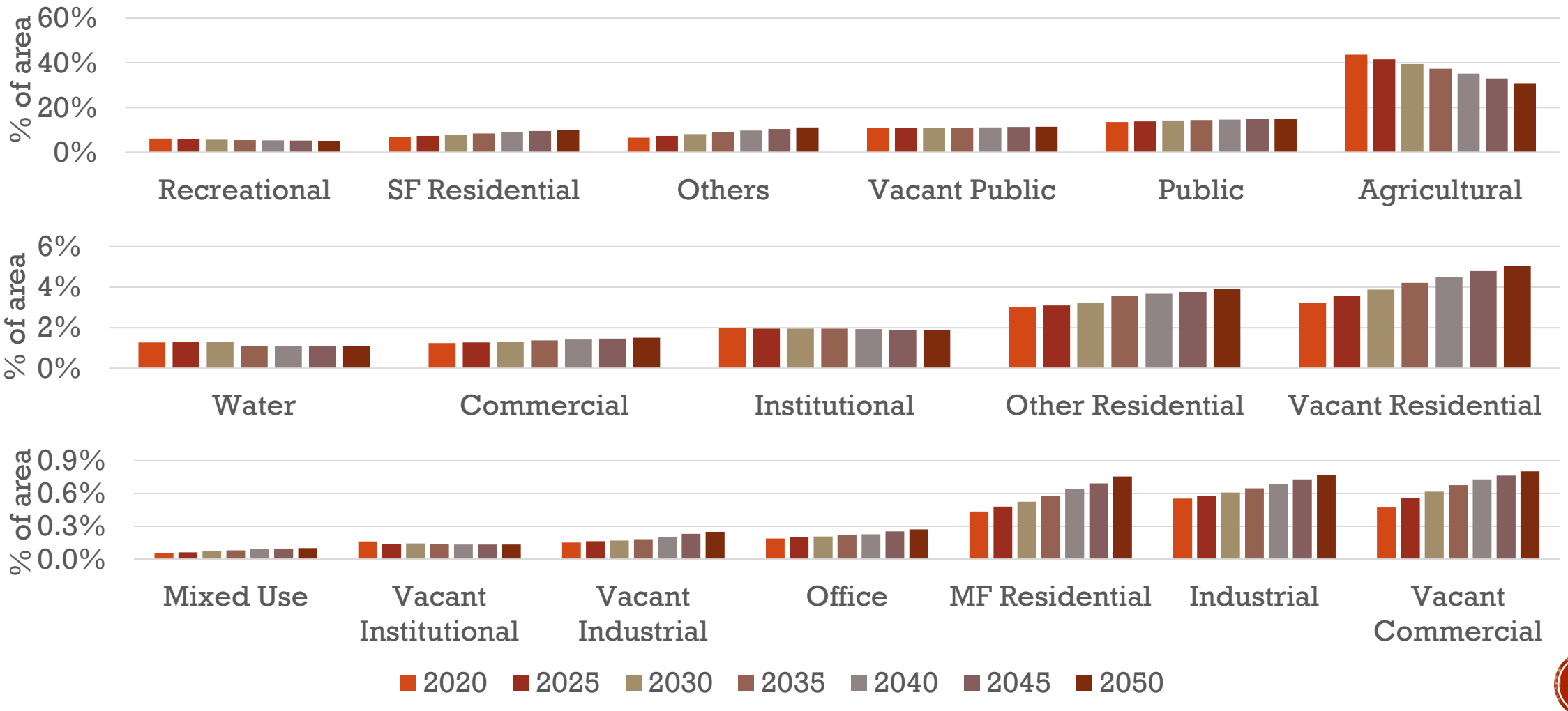


SIMULATION ENGINE VALIDATION



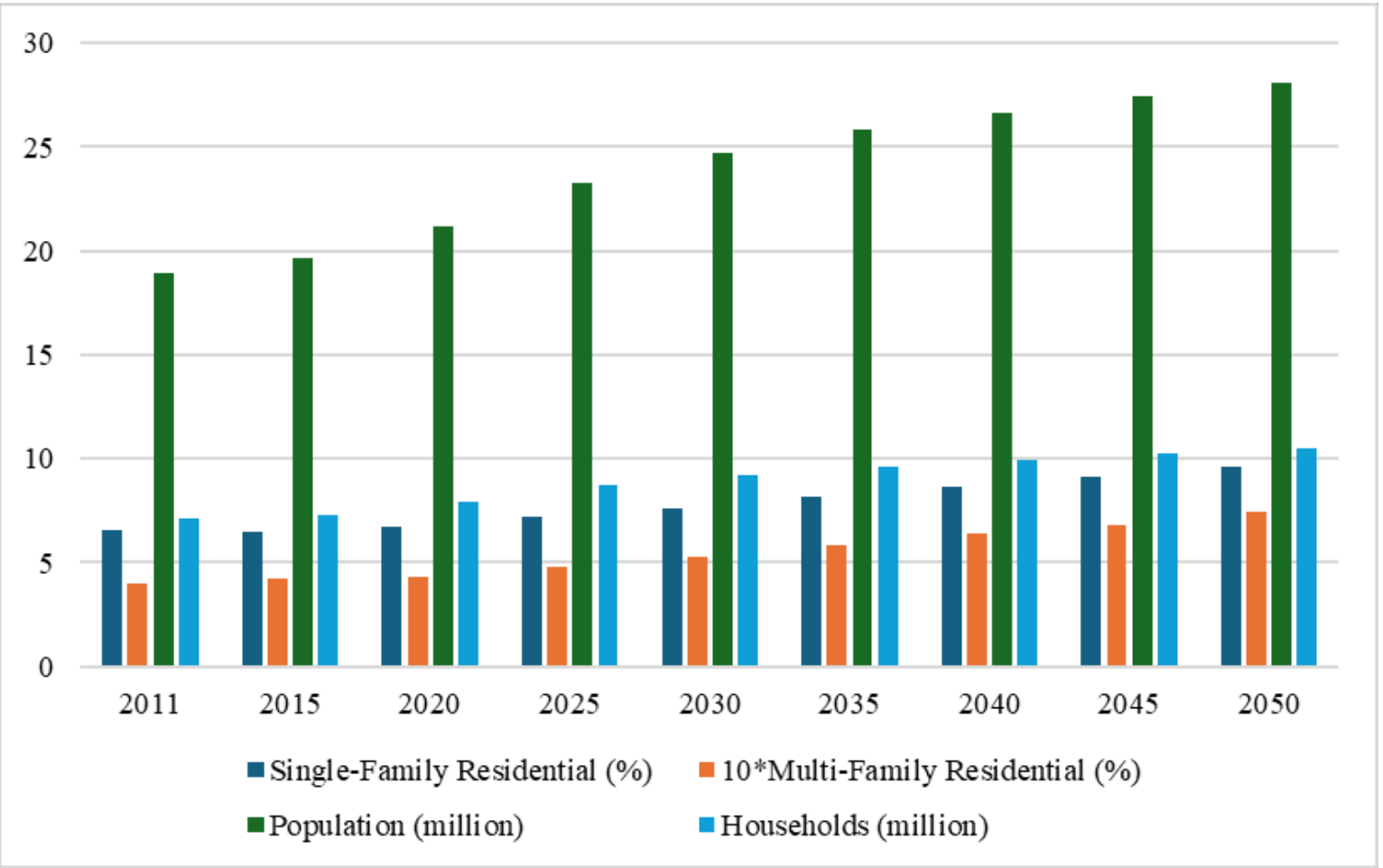
SIMULATION RESULTS

LAND USE AT THE STATE LEVEL (AREA)



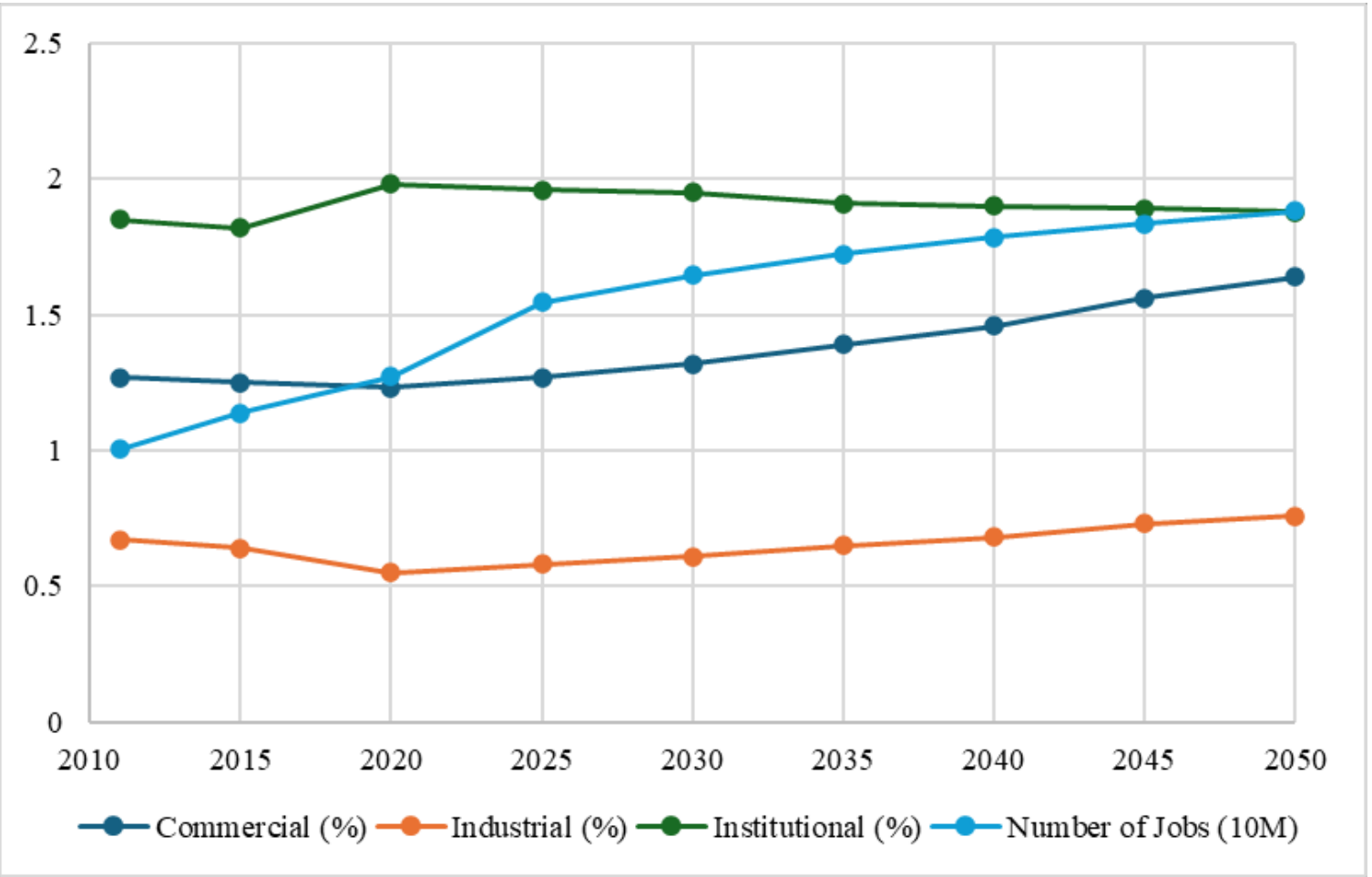
PREDICTION REASONABLENESS CHECKS

PREDICTION REASONABLENESS



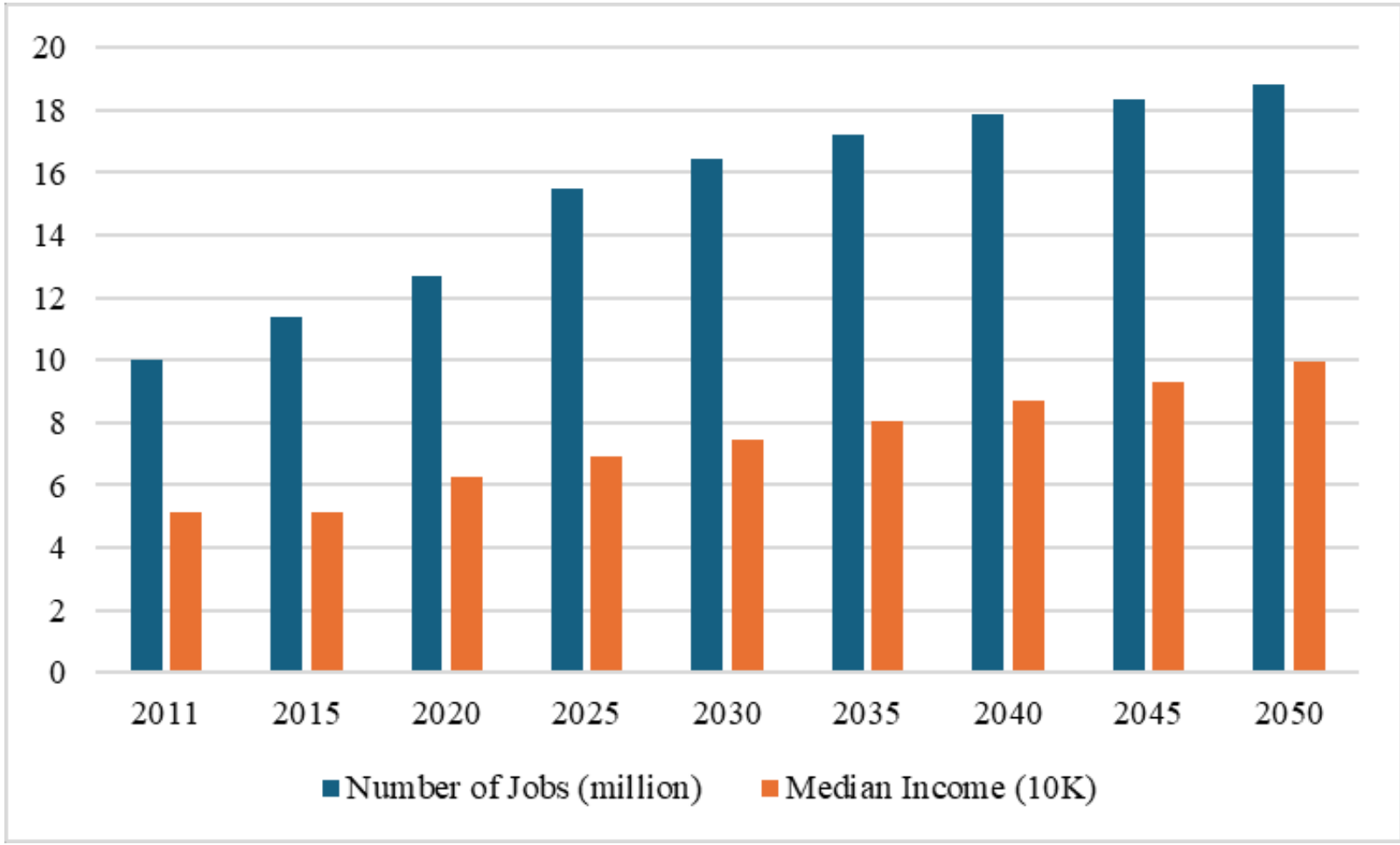
Residential Land Use, Population and Number of Households

PREDICTION REASONABLENESS



Commercial, Industrial and Institutional Land Uses and Number of Jobs

PREDICTION REASONABLENESS



Number of Jobs and Median Income

PREDICTION REASONABLENESS

Year	Population (million)	Number of Jobs (million)	Job per Capita
2011	18.90	10.04	0.53
2015	19.65	11.37	0.58
2020	21.22	12.72	0.60
2025	23.29	15.46	0.66
2030	24.70	16.44	0.67
2035	25.81	17.23	0.67
2040	26.68	17.85	0.67
2045	27.41	18.36	0.67
2050	28.07	18.81	0.67

Job per Capita by Year

PREDICTION RANDOMNESS

- We examine the consistency of the results from micro-simulator by running the predictions using different random number seeds
- For different draws of random numbers, land use change decisions change at the parcel level
- However, land use distribution at the aggregate levels e.g., block group, census tract and county should be consistent across the seeds

PREDICTION CONSISTENCY

Land Use	1st Run			2nd Run			3rd Run		
	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile
Agricultural	5.21	13.39	0.00,0.16,1.69	5.20	13.38	0.00,0.16,1.67	5.27	13.52	0.00,0.16,1.64
Commercial	7.74	11.88	0.73,3.13,9.52	7.69	11.84	0.72,3.12,9.36	7.69	11.90	0.71,3.08,9.44
Industrial	2.15	5.70	0.03,0.26,1.38	2.13	5.66	0.03,0.26,1.39	2.12	5.65	0.03,0.26,1.37
Institutional	2.00	5.30	0.13,0.53,1.92	1.98	5.23	0.13,0.52,1.91	2.01	5.29	0.13,0.53,1.95
Mixed Use	0.38	1.12	0.00,0.06,0.32	0.38	1.07	0.00,0.06,0.32	0.38	1.09	0.00,0.07,0.31
Multi-family Residential	5.88	11.38	0.48,1.62,5.77	5.91	11.38	0.49,1.64,5.85	5.90	11.42	0.48,1.61,5.75
Office	1.50	3.28	0.07,0.41,1.57	1.51	3.29	0.08,0.41,1.54	1.50	3.26	0.08,0.41,1.55
Other Residential	12.58	14.70	3.78,7.53,15.22	12.55	14.62	3.78,7.47,15.19	12.57	14.69	3.75,7.51,15.24
Others	4.73	8.25	0.52,1.56,5.34	4.80	8.36	0.53,1.55,5.44	4.74	8.19	0.52,1.57,5.34
Public	6.77	12.78	0.33,1.77,7.15	6.77	12.78	0.31,1.71,7.12	6.81	12.79	0.32,1.75,7.23
Recreational	2.05	5.19	0.18,0.58,1.64	2.06	5.30	0.18,0.57,1.66	2.09	5.28	0.17,0.58,1.72
Single-family Residential	34.20	25.45	12.55,29.78,52.07	34.25	25.51	12.57,29.89,52.11	34.20	25.46	12.64,29.72,52.18
Vacant Commercial	2.01	3.57	0.23,0.85,2.30	1.99	3.69	0.24,0.82,2.28	1.95	3.40	0.24,0.83,2.30
Vacant Industrial	0.39	1.59	0.00,0.01,0.14	0.40	1.61	0.00,0.01,0.15	0.39	1.61	0.00,0.01,0.15
Vacant Institutional	0.21	0.96	0.00,0.02,0.13	0.22	0.92	0.00,0.02,0.12	0.21	0.92	0.00,0.02,0.12
Vacant Public	4.24	9.90	0.23,0.94,3.45	4.23	9.83	0.23,0.94,3.52	4.22	9.90	0.23,0.93,3.46
Vacant Residential	6.77	10.87	1.15,3.37,7.94	6.78	10.91	1.16,3.38,7.90	6.79	11.02	1.15,3.37,7.80
Water	1.18	4.22	0.01,0.10,0.38	1.17	4.18	0.01,0.10,0.37	1.16	4.14	0.01,0.10,0.36

Block Group Level Consistency Check for 2050

PREDICTION CONSISTENCY

Land Use	1st Run			2nd Run			3rd Run		
	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile
Agricultural	6.37	13.99	0.07,0.44,3.53	6.31	13.92	0.07,0.43,3.47	6.37	13.99	0.07,0.44,3.53
Commercial	7.63	9.32	1.52,4.54,10.16	7.61	9.20	1.48,4.60,10.12	7.63	9.32	1.52,4.54,10.16
Industrial	2.37	5.18	0.13,0.56,1.95	2.39	5.24	0.13,0.55,2.00	2.37	5.18	0.13,0.56,1.95
Institutional	2.11	5.49	0.26,0.84,2.28	2.07	5.42	0.27,0.83,2.12	2.11	5.49	0.26,0.84,2.28
Mixed Use	0.37	0.88	0.03,0.13,0.40	0.36	0.79	0.03,0.13,0.40	0.37	0.88	0.03,0.13,0.40
Multi-family Residential	5.07	8.03	0.67,2.20,5.83	5.06	8.01	0.69,2.23,5.82	5.07	8.03	0.67,2.20,5.83
Office	1.51	2.69	0.20,0.66,1.75	1.52	2.77	0.19,0.66,1.75	1.51	2.69	0.20,0.66,1.75
Other Residential	11.38	11.17	4.33,7.83,14.74	11.41	11.20	4.32,7.94,14.36	11.38	11.17	4.33,7.83,14.74
Others	5.31	7.69	0.87,2.47,6.87	5.37	7.78	0.86,2.52,6.89	5.31	7.69	0.87,2.47,6.87
Public	8.11	13.21	1.12,3.56,9.22	8.05	13.17	1.04,3.51,9.01	8.11	13.21	1.12,3.56,9.22
Recreational	2.37	5.28	0.33,0.87,2.20	2.32	5.23	0.33,0.87,2.12	2.37	5.28	0.33,0.87,2.20
Single-family Residential	31.32	21.67	13.48,28.04,45.60	31.36	21.74	13.31,28.29,45.89	31.32	21.67	13.48,28.04,45.60
Vacant Commercial	1.94	2.66	0.43,1.13,2.44	1.94	2.80	0.44,1.12,2.41	1.94	2.66	0.43,1.13,2.44
Vacant Industrial	0.43	1.39	0.01,0.06,0.26	0.45	1.41	0.01,0.06,0.29	0.43	1.39	0.01,0.06,0.26
Vacant Institutional	0.22	0.97	0.01,0.05,0.17	0.23	0.94	0.01,0.05,0.17	0.22	0.97	0.01,0.05,0.17
Vacant Public	5.23	10.74	0.55,1.63,4.60	5.26	10.74	0.55,1.67,4.59	5.23	10.74	0.55,1.63,4.60
Vacant Residential	6.36	8.73	1.57,3.85,7.81	6.36	8.66	1.57,3.83,7.84	6.36	8.73	1.57,3.85,7.81
Water	1.24	3.82	0.05,0.16,0.59	1.27	3.88	0.05,0.17,0.59	1.24	3.82	0.05,0.16,0.59

Census Tract Level Consistency Check for 2050

PREDICTION CONSISTENCY

Land Use	1st Run			2nd Run			3rd Run		
	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile	Mean	Std. Dev.	25th,50th,75th Percentile
Agricultural	30.73	19.48	14.32,27.05,45.36	30.49	19.19	14.29,27.43,43.89	30.77	19.18	15.07,28.19,44.55
Commercial	1.55	1.71	0.49,1.00,2.07	1.39	1.16	0.41,1.04,2.08	1.40	1.18	0.46,0.94,2.07
Industrial	0.65	0.66	0.27,0.42,0.84	0.65	0.67	0.25,0.42,0.82	0.67	0.66	0.25,0.52,0.75
Institutional	1.47	4.39	0.26,0.48,0.92	1.46	4.40	0.25,0.45,0.77	1.43	4.38	0.26,0.42,0.77
Mixed Use	0.10	0.09	0.04,0.08,0.14	0.09	0.07	0.05,0.07,0.11	0.10	0.07	0.04,0.09,0.14
Multi-family Residential	0.70	0.66	0.27,0.44,0.90	0.73	0.70	0.27,0.49,1.00	0.72	0.66	0.29,0.49,0.93
Office	0.26	0.24	0.10,0.20,0.33	0.26	0.19	0.11,0.21,0.36	0.26	0.21	0.10,0.21,0.36
Other Residential	3.82	2.48	2.24,3.37,4.89	3.70	1.90	2.46,3.49,4.76	3.80	2.32	2.48,3.40,4.60
Others	10.21	8.33	6.19,8.43,11.53	10.50	8.28	6.61,8.42,11.03	10.01	8.32	5.92,8.13,10.60
Public	12.54	14.96	3.89,7.44,16.43	12.41	14.93	4.04,7.49,16.07	12.43	14.82	4.05,7.27,16.31
Recreational	4.21	8.57	0.33,1.04,4.03	4.17	8.44	0.32,0.97,3.82	4.46	9.61	0.30,1.10,3.69
Single-family Residential	10.08	5.60	6.68,9.77,12.88	10.05	5.62	6.45,9.85,12.83	10.18	5.52	6.42,10.00,12.70
Vacant Commercial	0.79	0.37	0.48,0.81,1.01	0.87	0.54	0.58,0.80,1.02	0.86	0.95	0.44,0.80,0.98
Vacant Industrial	0.21	0.17	0.10,0.17,0.27	0.21	0.18	0.09,0.15,0.27	0.23	0.17	0.10,0.19,0.32
Vacant Institutional	0.11	0.14	0.05,0.07,0.12	0.11	0.13	0.04,0.08,0.12	0.11	0.13	0.04,0.08,0.13
Vacant Public	8.39	10.92	1.20,2.83,12.55	8.60	11.11	1.15,3.19,12.56	8.32	10.97	1.18,2.86,12.11
Vacant Residential	4.96	2.51	3.11,4.68,6.85	5.06	2.48	3.34,4.64,6.80	5.01	2.49	3.27,4.59,6.60
Water	1.06	3.48	0.10,0.18,0.71	1.10	3.66	0.08,0.19,0.71	1.08	3.67	0.08,0.21,0.71

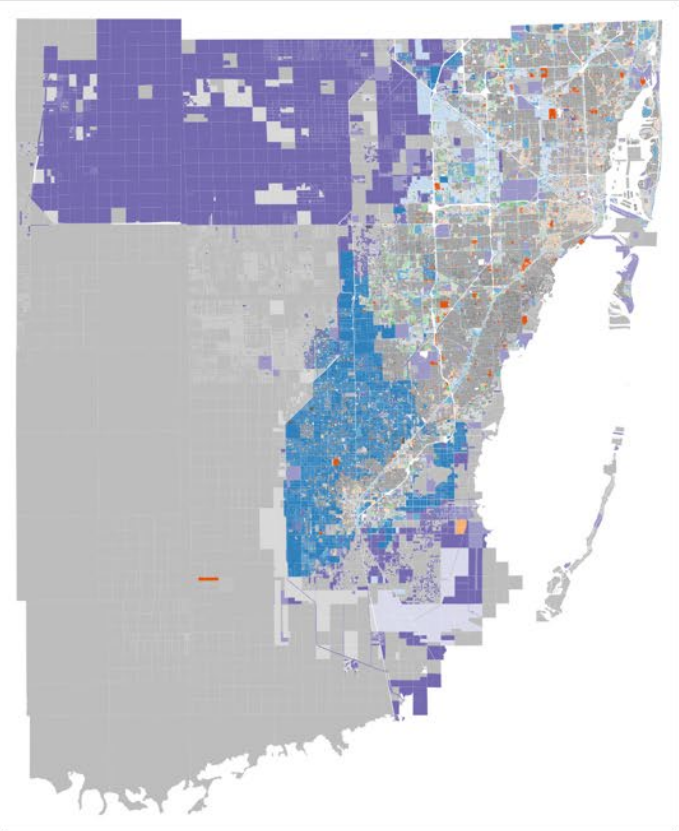
County Level Consistency Check for 2050

DATA PRODUCTS

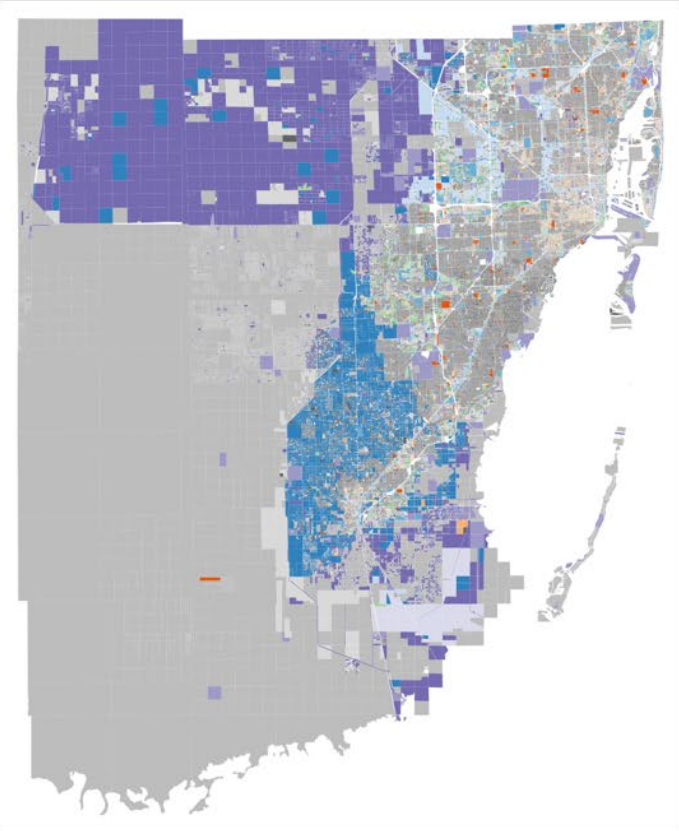
VARIABLE FORECASTS

- The research team has completed future data generation using the proposed framework
- Future forecasts are provided in two data formats: .CSV and shapefile
- The data are submitted through 3 different folders:
  - 🗂️ GIS Layers
  - 🗂️ Parcel Files
  - 🗂️ Aggregated Files
- GIS layers and parcel files contain parcel level land use forecasts from 2025 to 2050
- Aggregated data folder consists of block group, census tract and county level sociodemographic, land use and economic development variable forecasts

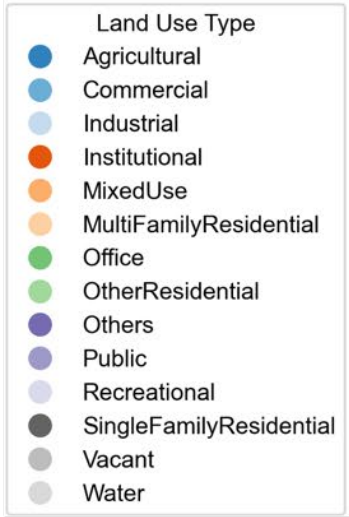
PARCEL DATA SAMPLE



Miami-Dade 2020

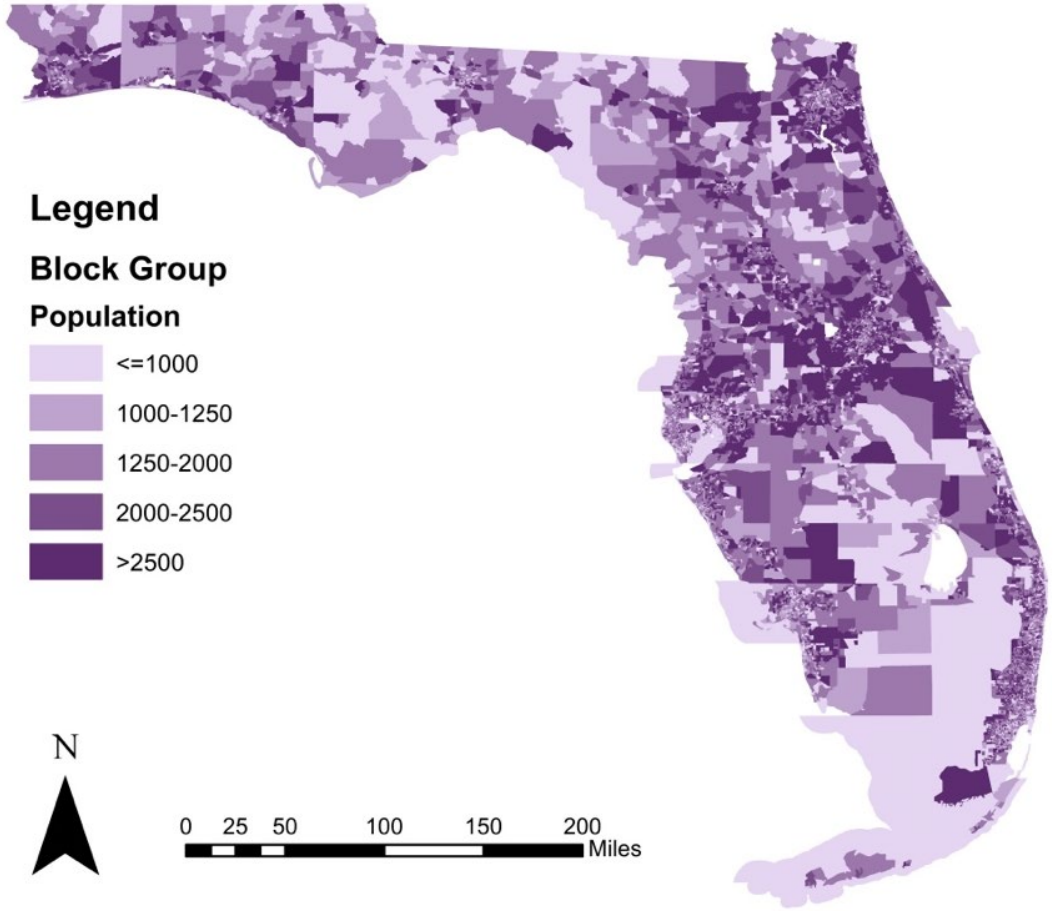


Miami-Dade 2025



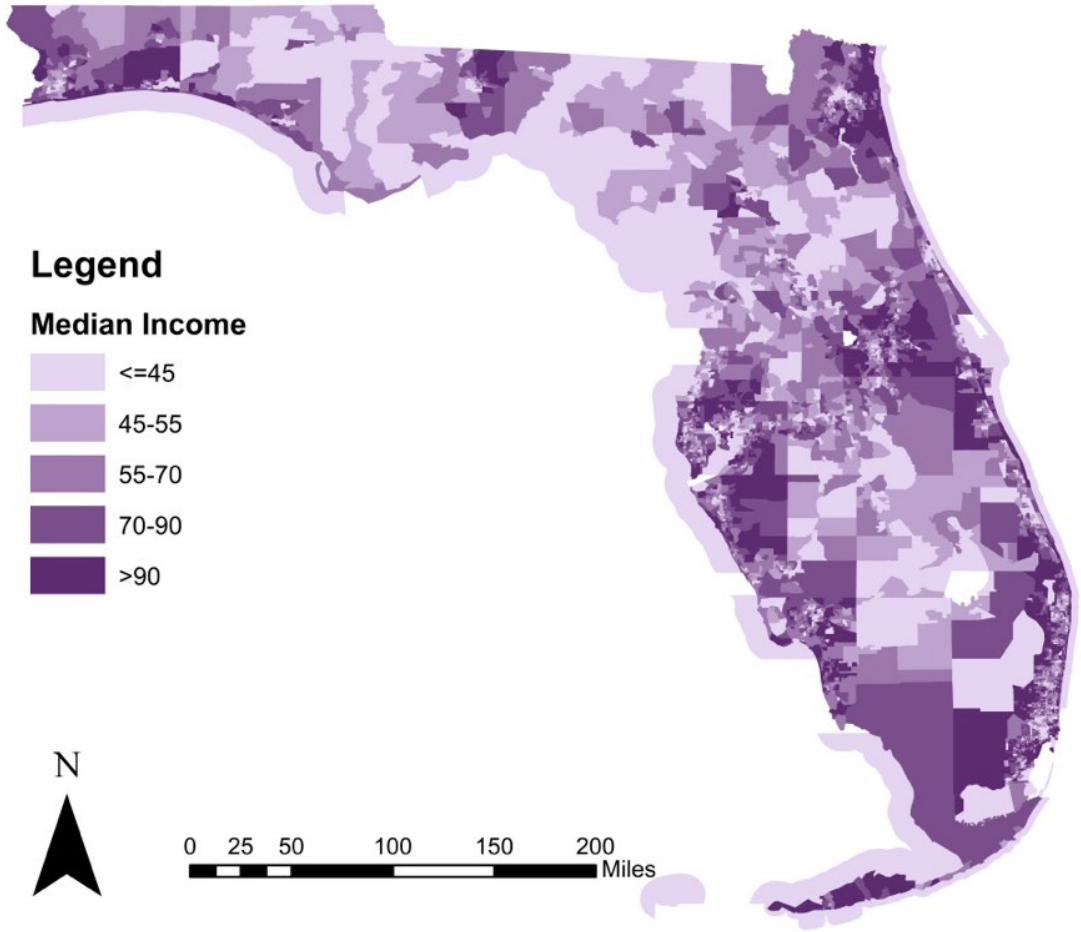
Parcel Level Land Use Forecast for 2025

BLOCK GROUP DATA SAMPLE



Block Group Population Forecast for 2025

CENSUS TRACT DATA SAMPLE



Census Tract Median Income Forecast for 2025

TAKEAWAYS

We developed a standard sociodemographic, land use and economic indicator framework for Florida

Land use changes at the parcel level in open-source software that can be aggregated at any resolution including BG, CT and county for ready adoption in Florida

Several potential Use cases are identified for future adoption of these data products

The data presented should be available for all of you to use from FDOT

ACKNOWLEDGEMENTS

- Team Members
  - Sudipta Tirtha
  - Lauren Hoover
  - Md Istiak Jahan
  - Dewan Parvez
  - Susmita Sarker
- Others
  - Sheldon Harrison
  - Krishnan Viswanathan
- FDOT personnel
  - Thomas Hill (program manager and main advocate)
  - Vladimir Majano
  - Terry Corkery

QUESTIONS

- For more details - https://people.cecs.ucf.edu/neluru/
- Email: naveen.eluru@ucf.edu