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Project: Development of a High-resolution Statewide Socio-demographic, Land Use and Economic Development Framework for Transportation Planning

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16. Abstract

The main objective of this research is to develop a standardized high resolution state-wide sociodemographic, land use and economic development model framework that will provide inputs for current transportation planning models. The developed framework is analogous to the Florida Standard Urban Transportation Model Structure (FSUTMS) model. The research team considered three groups of variables for inclusion in the model framework including sociodemographic, land use and economic development variables. For the variables identified, the research team processed data from various publicly available sources at the spatial resolution of interest including U.S. Census Bureau, American Community Survey, Florida Department of Revenue, Bureau of Economic Analysis, Federal Emergency Management Agency, Florida Natural Areas Inventory, Bureau of Economic and Business Research, and FDOT Roadway Characteristics Inventory and Florida Geographic Data Library. The research team has finalized the model framework and generated future forecasts for the selected variables. The outputs of this research effort include data products of sociodemographic, land use and economic development variables for every five-year period from 2025 through 2050 for the entire state in three spatial resolutions (block group, census tract and county).

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EXECUTIVE SUMMARY

The main objective of this research is to develop a standardized high resolution state-wide sociodemographic, land use and economic development model framework that will provide inputs for current transportation planning models. The developed framework is analogous to the Florida Standard Urban Transportation Model Structure (FSUTMS) model. The research team considered three groups of variables for inclusion in the model framework including sociodemographic, land use and economic development variables. For the variables identified, the research team processed data from various publicly available sources at the spatial resolution of interest including U.S. Census Bureau, American Community Survey, Florida Department of Revenue, Bureau of Economic Analysis, Federal Emergency Management Agency, Florida Natural Areas Inventory, Bureau of Economic and Business Research, and FDOT Roadway Characteristics Inventory and Florida Geographic Data Library. In this report, we document the overall process for generating the data outputs including positioning the work in the context of existing research, understanding stakeholder expectations, conceptualizing and developing data generation framework, data processing and model development, estimation and validation efforts, forecasting procedures, data generation for future time periods and avenues for data product application. The outputs of this research effort include data products of sociodemographic, land use and economic development variables for every five-year period from 2025 through 2050 for the entire state in three spatial resolutions (block group, census tract and county).

The report is organized as follows.

Section 1 provides an overview of the research effort and outlines the organization of the report.

Section 2 provided a detailed review of the literature on sociodemographic, land use and economic development variables in the literature. These studies encompass urban, regional, and state level modeling efforts for generating a subset of the socio demographic, land use and economic development variables. The land use models considered in this project can be broadly categorized into two groups: (a) independent land use models and (b) integrated models allowing for interactions between land use and transportation models. The section also outlines the different variables considered in travel demand models across the various studies.

In section 3, we present the details of a stakeholder survey and the results of the data analysis. the section provided information on the design and development of the study questionnaire, a summary of the data compiled and outlines insights on stakeholder expectations on sociodemographic, land use and economic data variables.

Section 4 outlines the rationale for variable selection from the three different variable categories - sociodemographic, land use and economic development. The section also provides a list of the selected variables and the associated data sources employed to generate these variables.

Section 5 documents the data sources employed for our analysis in the base year including details on the data processing procedures. The section also outlines processes employed for parcel data preparation, land use classification and compatibility across spatial resolutions. Finally, a data consistency analysis is conducted to highlight how trends from the data across the years are reasonable.

Section 6 provides a detailed description for the data generation framework with information on the various econometric model components. In this research, we mainly employ multinomial (binary for dichotomous dependent variables) logistic regression model, multinomial (binary) logit based fractional split model, and linear regression model for the analysis. The model framework details on the model system and forecasting approach are provided for each variable of interest.

In section 7, for the selected variables, we present the results of the various models estimated including details on the model structure and the different variables found to influence the variable of interest. The section provides details on the coefficients for each model clearly identifying the independent variables influencing the variable of interest. In the interest of space, a small number of model results are discussed in this section while the entire set of results are presented in the appendix.

Section 8 presents the forecasting procedure followed in this project to generate the data at a yearly interval for sociodemographic, land use and economic development variables. The forecasting procedure relies on a microsimulation approach that embeds the estimated econometric models for generating different probability profiles. The section also details procedures employed for natural conservation areas in the state.

In Section 9, we provide an overview of the prediction results from 2025 through 2050 in five-year increments documenting future sociodemographic, land use and economic development variables. The results are provided for sociodemographic, economic and land use variables for the various time periods. Further, a prediction consistency analysis is conducted to ensure the model outputs follow expected trends over time.

Section 10 provides detailed instructions on how to use the data files generated from this project that encompass the entire state in three spatial resolutions (block group, census tract and county) and are provided in .csv and shapefile formats for each five-year increment.

Finally, Section 11 concludes the report and offers cautionary remarks on how to use these data products.

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1 INTRODUCTION

The main objective of this research is to develop a standardized high resolution state-wide sociodemographic, land use and economic development model framework that will provide inputs for current transportation planning models. The developed framework is analogous to the Florida Standard Urban Transportation Model Structure (FSUTMS) model. The research team considered three groups of variables for inclusion in the model framework including sociodemographic, land use and economic development variables. For the variables identified, the research team processed data from various publicly available sources at the spatial resolution of interest including U.S. Census Bureau, American Community Survey, Florida Department of Revenue, Bureau of Economic Analysis, Federal Emergency Management Agency, Florida Natural Areas Inventory, Bureau of Economic and Business Research, and FDOT Roadway Characteristics Inventory and Florida Geographic Data Library. Further, the research team finalized the model framework and generated future forecasts for the selected variables. The outputs of this research effort include data products of sociodemographic, land use and economic development variables for every five-year period from 2025 through 2050 for the entire state that in three spatial resolutions (block group, census tract and county). In this report, we document the overall process for generating the data outputs including positioning the work in the context of existing research, understanding stakeholder expectations, conceptualizing and developing data generation framework, data processing and model development, estimation and validation efforts, forecasting procedures, data generation for future time periods and avenues for data product application.

The remainder of the report is organized as follows. Section 2 provided a detailed review of the literature on sociodemographic, land use and economic development variables in the literature. In section 3, we present the details of a stakeholder survey and the results of the data analysis. Section 4 documents the list of specific variables to be considered across the different variable categories in this project. Section 5 documents the data sources employed for our analysis in the base year including details on the data processing procedures. Section 6 provides a detailed description for the data generation framework with information on the various econometric model components. In this research, we mainly employ multinomial (binary for dichotomous dependent variables) logistic regression model, multinomial (binary) logit based fractional split model, and linear regression model for the analysis. In section 7, for the selected variables, we present the results of the various models estimated including details on the model structure and the different variables found to influence the variable of interest. Section 8 presents the forecasting procedure followed in this project to generate the data at a yearly interval for sociodemographic, land use and economic development variables. The forecasting procedure relies on a microsimulation approach that embeds the estimated econometric models for generating different probability profiles. In Section 9, we provide an overview of the prediction results from 2025 through 2050 in five-year increments documenting future sociodemographic, land use and economic development variables. Section 10 provides detailed instructions on how to use the data files generated from this project that encompass the entire state in three spatial resolutions (block group, census tract and county) and are provided in .csv and shapefile formats for each five-year increment. Finally, Section 11 concludes the report.

2 LITERATURE REVIEW

2.1 Modelling Frameworks and Common Modules

The research objectives include generating and forecasting three categories of variables - socio demographic, land use and economic development - for consideration in existing travel demand models. The reader would note that this is an ambitious goal given that several research groups are dedicated to forecasting each category of these variables. To manage the scope of the research effort, the research team will focus on land use variable forecasting while drawing on some of the socio-demographic and economic development variables (if available) from reputed state or federal agencies. In the event that these variables are not available at the jurisdiction of choice for our model framework, the data obtained will serve as control totals for our methods. Thus, the emphasis of our research is on developing a high resolution interconnected land use and transportation modules with exogenous inputs for socio-demographic and economic variables. Thus, in this section, we conduct a review on such interconnected transportation and land use modeling frameworks.

Given the long history of transportation and land use modeling frameworks in transportation and urban planning fields, an exhaustive review of all prior modeling approaches in literature is beyond the scope of our research. Hence, in our review, we examined 12 application studies and 12 academic studies that are relevant to the research objectives. These studies encompass urban, regional, and state level modeling efforts for generating a subset of the socio demographic, land use and economic development variables. The land use models considered in this study can be broadly categorized into two groups: (a) independent land use models and (b) integrated models allowing for interactions between land use and transportation models. The distinction between the two groups is based on how the relationship between land use patterns and potential interactions with socio-demographic factors, economic indicators, mobility demand, transportation infrastructure and/or other relevant modules are accommodated. In the first group of studies, the complex interactions across these dimensions are not considered. The second group of studies accommodates for these interactions considering data and models for several modules.

Across these two groups of studies, the dependent variable considered is the evolution of land use type over time. The land use type variable, based on study objectives, is categorized into several alternatives ranging between 6 and 15. For example, Liu et al. (2017) focused on identifying land use and land cover change due to human activities and climate change. This study considered six land use categories including Cultivated land, Forest land, Grass land, Water area, Urban land, and Unused land. Iacono & Levinson (2009) quantified the interaction between transportation networks and land use where 10 land use categories were considered including airports, commercial, highway, industrial, parks, public, railroads, residential, vacant, and water. Prior to detailing a study-by-study summary of the studies, we focus on discussing the details of components that are likely to appear typically across these model systems. The discussion is organized along sub-sections as follows: (1) spatial resolution, (2) synthetic population generator, (3) mathematical approaches, (4) macroeconomic model, (5) relocation models, (6) development models, (7) transportation planning models, and (8) independent variables.

2.1.1 Spatial Resolution

Land use model systems are generated for various spatial resolutions in the literature. The spatial resolution selection for model development is based on data availability, land use patterns, and study objectives. The selection of appropriate spatial unit size is important for effective operation and computational performance of the models (Türk and Zwick, 2019). The finest resolution considered in land use modeling is the parcel resolution. Newman et al. (2016) forecasted vacant land use at the parcel level using artificial neural network (ANN). Similarly, Future Land Use Allocation Model identified developable parcels in the FDOT District 5 region. Grid-based representation of space is the most dominant approach in literature as it offers a simplified method to uniformly divide a region (Pijanowski et al., 2022). From our review, we observe that grid size varies from 28.5m*28.5m to 300m*300m. In high resolution approaches (models with small grid sizes) grid cells are assigned a land use type classification typically based on the dominant proportion category among land use categories (Liu et al., 2017). In models systems with larger spatial units (such as TAZ), all land-use category proportions are accommodated. Among the reviewed studies, TAZ level analysis is employed in FLUAM, LUSDR and G-LUM land use models (Plath, 2015; Gregor, 2007; Paul, 2009).

2.1.2 Synthetic Population Generator

In the development of mathematical models for generating land use variables, synthetic population generators (SPGs) are commonly employed in land use models. SPGs synthesize simulated agents to represent their real-world counterparts including households, employment, firms, and developers. SPG agents are generated for spatial resolutions based on control total data available for various agents. For example, households are generated using Census microdata such as public use microdata sample (PUMS). Using the SPG base year data, population updating systems incorporate possible changes in the households (including but not limited to increase/decrease of household size (due to birth of a child, death of a member), change of employment status, separation and merging of households and household moves) to evolve the population over time (Moeckel et al., 2007; Eluru et al., 2008). Land use models considering SPGs include UrbanSIM (Waddell, 2002), ILUMASS (Moeckel et al., 2007), LUSDR (Gregor, 2007), PUMA (Ettema et al., 2007), RAMBLAS (Veldhuisen, 2000) and MARS (Pfaffenbichler et al., 2008).

2.1.3 Mathematical Approaches

The mathematical approaches employed within land use modeling studies are closely aligned with mathematical models for categorical analysis. The dependent variables either take the form of (a) binary variables (such as yes/no decision for land development, cell vacancy), and (b) polychotomous variables (more than 2 alternative categories). The approaches employed to analyze these variables include multinomial logit model (binary logit in case of 2 alternatives), cellular automata (CA), artificial neural network (ANN), Markov chain and combined Markov-CA model.

In MNL approach, utility of an alternative is formulated as a function of independent variables (relevant to the variable modeled) and model parameters are estimated by maximizing the log-likelihood function to improve the predicted probability of the chosen alternative. In cellular automata (CA) model, feature cells are first identified which do not change over time (for example, cells located in conservation areas). For the remaining cells, land use change potential is computed for each land use types using site attributes, accessibility measure and neighborhood characteristics. Finally, future land use is simulated for each cell using a transition rule. ANN is a deep learning algorithm consisting of three layers: input layer, hidden layer, and output layer. Each layer consists of interconnected nodes with an assigned weight. The weights are assigned using forward and backward propagation. In forward propagation, the weights are multiplied with the features to predict the outcome and the classification error is estimated. In backward propagation, the weights are updated based on the error estimated in the previous step. Finally, few studies employed Markov chain approach for land use simulation. Markov chain is a stochastic approach which assumes that probability of a cell converting to other land use types depends on the current state of the cell. The transition is identified probabilistic distributions based on data. Across various land use model systems, typically, a sequence of models is considered to incorporate the various decision processes. It is possible to consider a mix of the various methods outlined above across a single land use model.

2.1.4 Macroeconomic Model

While land use models are developed for city, regional or states, the evolution of land use patterns is affected by macroeconomic conditions. The macroeconomic model system provides externally imposed control totals to determine overall target attribute values for various measures (Waddell, 2002) including demographic characteristics (such as population and number of households) and economic characteristics (such as number of firms and employment). The model will regulate the overall changes at the study region level to ensure plausible results. For example, Bureau of Economic and Business Research projects county level population in Florida using historical Census data. Such external population measures control total population in a year for the study region.

Household and employment models are developed to estimate future household and employment changes at an aggregate resolution (such as TAZ). The models considered (such as number of new households) are forecasted using regression or Tobit regression models. The independent variables considered include site characteristics (proximity to coast, urban growth boundary, percent of undeveloped and vacant land), transportation infrastructure (proximity to arterials and interchange) and local accessibility measures.

2.1.5 Relocation Models

The evolution of land-use patterns is influenced by household and employment relocation decisions. In the relocation models, the likelihood of following events are analyzed: (a) whether a household decides to move or not, (b) whether a jobholder/firm decides to move or not, and (c) for agents identified to move determine their destination. The mobility decisions are modeled based on available historical data for the study region (for example see UrbanSim). Traditionally, these decisions are commonly modeled using binary logit models (see LandSys). Household mobility is a function of synthetic household characteristics (such as household size, age, income), and grid cell attributes (such as vacant dwelling units, owner occupancy). On the other hand, employment mobility decision is predicted based on employment characteristics, cell attributes (such as neighborhood attributes and land price) and transportation accessibility. The employment relocation decision is implemented either at the employee resolution or the firm resolution (see ILUMASS).

For agents selected to relocate, the potential location is modeled based on multinomial logit model. As the number of potential alternatives for relocation in the study region can be a large number, the estimation models employ sampling approaches within the multinomial logit model structure.

In household location model, independent variables considered include cell level housing characteristics (price, density, and age), neighborhood characteristics (land use mix, density, average property values, and local accessibility to retail), accessibility to jobs. Independent variables considered in employee job location model include cell level characteristics (price, type of space, density, and age), neighborhood characteristics (average land values, land use mix, and employment), and local accessibility. In the firm location model, a firm selects one of the locations from the suitable choice list if it offers a significant improvement of locational satisfaction (Moeckel et al., 2007). The MNL models estimated are coupled with Monte Carlo simulation approach to generate future location choices for all agents.

2.1.6 Development Models

In various land use frameworks, detailed models of land development model processes are developed. These modules include development decision processes, land price model and market equilibrium. The development decision module simulates developers' choices regarding demolition, new development, and location of the development. The choices are modelled using multinomial logit model. In the demolition decision model, independent variables considered include demolition costs, maintenance costs, and rent of existing location. In modeling the new development and location decisions, grid cell attributes (current development, rent, policy constraints, and construction and maintenance costs) and transportation infrastructure (proximity to highways, arterials) are considered. Land price model is employed to predict the price of each grid. The model component employs hedonic regression model. The variables considered in the model include site attributes, regional and local accessibility, and policies on land prices (see example land price model in UrbanSim).

Land use simulation models (such as LandSys and LandSys II) consider market equilibrium in the simulation process to address the interaction of developer and household decisions. Generally, market equilibrium component is integrated with relocation model and development model. This component ensures that supply and demand for new home (job) locations are in an equilibrium. The existing models employ multi-objective optimization techniques to achieve this equilibrium. For example, LandSys model simultaneously maximizes supply and demand of cells, and the land use supply–demand market achieves equilibrium when all agents are assigned to the developed land cells.

2.1.7 Transportation Planning Model

In an integrated land use transportation model system, land use and transportation planning models interact with each other. The outputs from land use models are considered as inputs to the transportation model and vice-versa. For example, land use model outputs are considered in travel demand prediction, and travel costs estimated with updated land use data are employed in land use model in the next iteration. Among the existing model frameworks, UrbanSim, ILUMASS and MARS accommodate the interaction between these two model components.

2.1.8 Independent Variables

Independent variables across different model components can be broadly categorized into 5 groups: site attributes, socio-demographic characteristics, transportation infrastructure variables, economic development variables and local accessibility measures. Site attributes include cell specific physical attributes (such as slope, aspect, elevation, and soil condition), neighborhood characteristics (such as land use), land price, quality of view and distance to lake, river, recreational centers, and urban area. Socio-demographic characteristics can be broadly classified into two groups: household characteristics and aggregate characteristics. Household level attributes are derived from synthesized population which include household size, number of workers, age of household head. Zonal level characteristics include census tract, buffer area and grid level population, home ownership level, education, ethnicity. Transportation infrastructure variables include transportation network density, proximity to arterials, county roads, highways, and interchange. Economic development variables include median income, poverty rate, gross domestic product, density of industries, airports, and town centers. Local accessibility measures include travel costs, proximity to service center, shopping, employment, and central business district (CBD).

2.2 Summary of Literature Review

In this section, a summary of various studies reviewed for our analysis is provided. The summary is organized along two groups. The first group of studies examine independent land use models. The second group of studies recognize that land use changes are interconnected with aforementioned factors and accommodate for these interactions within the mathematical frameworks. It is important to recognize that integrated model systems are comprehensive and data intensive to account for the interplay between several model components.

2.2.1 Independent models

In this research, we have reviewed 13 independent land use models and the review findings are summarized in Table 1. In this table, we provide details of study region, study period, study objectives, spatial resolution, output variables, agents considered, forecasted year and time between each iteration, methods and independent variables considered. From the table, it is evident that majority of the studies (11 out of 13) identify land use at the grid/cell level and grid size varies from 28.5m*28.5m to 100m*100m. The remaining 2 studies (Newman et al., 2016 and Future Land Use Allocation Model) analyze land use patterns at the disaggregate level of parcel. Output variables can be broadly categorized into two groups: binary variables and land use type variables. Binary variables considered in land use modelling include vacant/non-vacant, construction/no construction, urban/non-urban distribution. Land use variable indicates future land use type and number of land use categories considered varies from 6 to 15. From Table 1, it is also found that agent-based simulation is not commonly employed by independent models. Only one study (Ralha, et al., 2013) used multi-agent based system and considered ranchers, farmers, developers, conservation agents. The table also indicates that time between two subsequent forecasts varies across the studies (1 to 10 years). Mathematical approaches employed in these studies include multinomial logit model (binary logit in case of 2 alternatives), cellular automata (CA), artificial neural network (ANN), Markov chain and combined Markov-CA model. Finally, independent variables considered can be grouped into five categories: site attributes, socio-demographic characteristics, transportation infrastructure variables, economic development variables and local accessibility measures.

Table 1 Review of Independent Land Use Models

Study (Study Region; year)	Objectives	Spatial Resolution	Output variables	Agents Considered	Forecasted year (time between each prediction)	Methods	Independent variables considered
Pijanowski et al., 2002 (Michigan's Grand Traverse Bay Watershed; 2000)	To forecast land use changes over large regions using GIS and neural network	Grid level (100m*100m)	Locations of urban development	--	2020 (10 years)	Artificial neural networks (ANN)	Site variables (quality of view, agricultural area-1 mile buffer, and distance to lake, river, recreational centers, and urban area), and Transportation infrastructure variables (proximity to highways, county roads and residential streets)
Newman et al., 2016 (Fort Worth, Texas; 1990-2010)	To forecast vacant land	Parcel	Binary variable (vacant or not)	--	2020 (5 years)	ANN	Site Variables (market value, house value, vacancy rate), Socio-demographic factors (income, poverty rate, home ownership level, education, ethnicity), Transportation Infrastructure (proximity to highway and railroad) and Economic development factors (density of service and secondary industry)
Pijanowski et al., 2009 (Tehran Metropolitan Area, Iran; 1988-2000)	To simulate urbanization using urban expansion model	Grid level (28.5m* 28.5m)	Binary variable (construction and non-construction)	--	--	ANN	Site variables (building area, green space, and elevation, slope, aspect), Transportation Infrastructure (proximity to roadway), Local accessibility (proximity to service center)
Lui et al., 2017 (China; 2000-2010)	To simulate the long-term land-use change	Grid level (30m*30m)	Six land use types	--	2050 (40 years)	Cellular automata (CA), system dynamics (SD) and ANN	Site variables (slope, soil and climate condition), Socio-demographic (population), Economic development (Gross Domestic Product), Transportation infrastructure (roadway density)
Guan et al., 2011 (Saga,	To analyze temporal	Grid level	Six land use types	--	2042	Combined Markov–	Site variables (slope, elevation, distance to the

Study (Study Region; year)	**Objectives**	**Spatial Resolution**	**Output variables**	**Agents Considered**	**Forecasted year (time between each prediction)**	**Methods**	**Independent variables considered**
Japan; 1976-2006)	change and spatial distribution of land use					Cellular Automata model	nearest river, land price) Transportation infrastructure (distance to the nearest road), sociodemographic variables (population density), Economic development (GDP per capita)
Liang et al., 2018 (Guangdong Province, China; 2000-2013)	To propose a method to integrate various planning driving effects in urban growth simulation	Grid level (100m x 100m)	Urban and non-urban land distribution	--	2052 (1 year)	Markov Model, CA, and ANN	Site variables (slope, aspect), Socio-demographics (population), economic development (GDP, airports and town centers) and transportation infrastructure (proximity to national roads, provincial roads and highways)
Ralha, et al., 2013 (Brazil's Federal District; 2002)	To present a multi-agent model system to characterize land-use change dynamics	Grid level (one hectare)	Six land-use categories	Transformer agents such as ranchers, farmers, developers, conservative agents	2008	Multi-Agent System (MAS)	--
Subedi et al., 2013 (Saddle Creek drainage basin, Polk County, FL; 1995-2006)	To investigates the applicability of a hybrid (CA- Markov) model in predicting land-use change	Grid level	Eight land-use categories	--	2015 (9 years)	Markov Model and CA	Physical proximity to an existing land-use class
Turk & Zwick, 2019 (Hillsborough County, FL; 2010)	To perform a land assignment model	Grid level (100m x 100m)	Binary variable for each of 10 land uses	--	2040	Binary Integer Programming	Land use suitability score

Study (Study Region; year)	Objectives	Spatial Resolution	Output variables	Agents Considered	Forecasted year (time between each prediction)	Methods	Independent variables considered
Iacono & Levinson, 2009 (Twin Cities, Minnesota; 1990-2000)	To quantify the degree to which transportation networks impact changes in land use	Grid (75m*75m)	Land use type (10 categories)	--	--	Multinomial Logit Model (MNL)	Site characteristics (existing land use, neighbor land use), Transportation infrastructure (road dummy, road neighbor, accessibility)
Aljoufie et al., 2003 (Jeddah, Saudi Arabia; 1980-2007)	To study this mutual interaction between urban land-use change and transport	Grid level (100m*100m)	Land use type (land uses, feature land uses, and vacant land uses)	--	--	CA-based Land Use (MNL formulation) – Transport Interaction model	Site Attributes (zoning, physical suitability for development such as slope and soil condition), Local accessibility (proximity to roadway)
Guzman et al., 2020 (Bogotá, Colombia; 2007-2016)	To test different scenarios based on potential land-use policies, environmental suitability, and transport alternatives	Grid level (60×60m)	Land-uses type (15 categories)	--	2050 (10 years)	CA-based land use model (MNL formulation)	Site attributes (neighborhood potential, suitability such as presence of flood, landslide or fire risk, zoning), and Local accessibility
Future Land Use Allocation Model (District 5, FL)	To identify developable parcels in the study region	Parcel level	Binary variable (developed or not)	--	2030	Ranking method	Socio-demographic variables (single family and multi-family population, school enrollment) and economic development (total employment and employment by industry)

2.2.2 Interconnected models

In this research, we have reviewed 11 interconnected land use models and the review findings are summarized in Table 2. In this table, we document model, study region, spatial resolution, model components, methods, agents considered, forecast year and time between each iteration, and independent variables considered. Table 1 tabulates the details of following land use models: UrbanSIM, FLUAM, ILUMASS, SLEUTH, LandSys, LandSys II, LUSDR, PUMA, G-LUM, MARS and LUCIS. Most of the reviewed models consider grid/cell (8 out of 11) as the spatial unit of analysis and grid size varies from 50m*50m to 300m*300m. The remaining 3 models (FLUAM, LUSDR and G-LUM) simulate land use change at the traffic analysis zone (TAZ) level. It is also evident from our review that interconnected models consist of several model components including macroeconomic model, cellular automata, mobility model, relocation model, development model, land price model, transportation planning model and market equilibrium model. Multinomial logit model (MNL) is most commonly used in cellular automata, mobility model, relocation model, and development model. Land price is forecasted using linear regression model and market equilibrium is achieved by optimization techniques. Monte Carlo simulation approaches are employed by a subset of land use models (ILLUMASS and SLEUTH). Among the reviewed land use models, seven models (out of 11) are agent-based models, and these studies consider households, firms, employment, and developers as the agents. From Table 2, it is also evident that the time interval between two subsequent simulations varies across the models from 1 to 5 years. Similar to independent land use models, independent factors considered in interconnected models can be grouped into five categories: site attributes, socio-demographic characteristics, transportation infrastructure variables, economic development variables and local accessibility measures.

2.3 Variables Considered in TDMs

In this section, we highlight socio-demographic, land use and economic development variables employed in existing travel demand models. The results are presented in tables 3 through 5. In Table 3, we identify the variables for different model components of trip based TDMs. In Table 4, we identify the zonal level variables considered in activity based TDMs. In Table 5, we identify variables considered in disaggregate level studies modelling household level vehicles miles travelled (VMT), home based non-work trips, intrazonal/interzonal trip choice and model choice. From the tables, it is evident that the commonly used socio-demographic variables include population, number of households, age distribution, gender, race, number of children, school enrollment, education status, and vehicle ownership level. The most commonly employed land use variables include land use mix/diversity variable, recreational area, institutional business center density, roadway density, railway density, bike lane density, sidewalk density, metro station density, bus station and network density, accessibility to jobs, and number of hotel/motels. Land use mix/diversity variable indicates level of heterogeneity in land use of a spatial unit. Thus, readers should note that area or proportion of various land use types (e.g., residential, industrial, retail and institutional) need to be estimated to calculate land use mix/diversity variable. The most commonly employed economic development variables include income, employment density, retail employment density, population-employment balance, average number of workers per household, retail density, business and shopping center density.

Table 2 Review of Integrated Model Systems

Study (Model)	Study Region	Spatial Resolution	Model components	Methods	Agents	Forecasted year (time between each prediction)	Independent Variables
Waddell, 2002 (UrbanSIM)	Eugene-Springfield, Oregon	Grid Level (150m*150m)	Macroeconomic Model	--	Households, employment, and developers	2045 (1 year)	Site characteristics (current development, policy constraints, and land and improvement values), Transportation infrastructure (proximity to highways, arterials) and Local accessibility (proximity to shopping, employment, and central business district)
			Mobility Model	Multinomial logit model (MNL)			
			Location Model	MNL			
			Real Estate Development Model	MNL			
			Land Price Model	Linear regression model			
			Local and Regional Accessibility	Transportation demand model			
Plath, 2015 (FLUAM)	Florida	Traffic Analysis Zone (TAZ)	Land development model	MNL model	--	2020 (5 years)	Site characteristics (proximity to coast, urban growth boundary, percent of undeveloped and vacant land), Transportation infrastructure (proximity to arterials and interchange, accessibility measure)
			Household model	Tobit model			
			Employment model	Tobit model			
Moeckel et al., 2007 (ILUMASS)	Dortmund, Germany	Grid Level (100m*100m)	Land-Use Model, Transportation Model and Environmental Impact Model	Monte Carlo Simulation	Household, firm and developer	2030 (1 year)	Transportation Infrastructure variables
Clarke et al., 1997 (SLEUTH)	San Francisco, Chicago, Washington-Baltimore, and Sioux Falls	Grid Level (300m*300m)	Cellular automata, terrain mapping, and land cover deltatron model	Monte Carlo Simulation	--	N/A	Site variables (slope, hill-shade, existing land-use, excluded areas, urban development), Transportation infrastructure (network density)

Study (Model)	Study Region	Spatial Resolution	Model components	Methods	Agents	Forecasted year (time between each prediction)	Independent Variables
Zhao and Peng, 2012 (LandSys)	Orange County, Florida	Grid Level (50m*50m)	Cellular Automata (CA) Model	Multinomial logit model (MNL)	Household, Firm, and Developer	2025 (1 year)	Site variables (elevation, soil condition, land use/cover data, zoning boundary data) and Local accessibility (travel time)
			Mobility Model	MNL			
			Location Model	MNL			
			Development Model	MNL			
			Market Equilibrium	Optimization			
Zhao and Peng, 2015 (LandSys II)	Orange County, Florida	Grid Level (50m*50m)	Cellular Automata (CA) Model	ANN	Household, employment, and developer	2025 (1 year)	Site variables (elevation, soil condition, land use/cover data, zoning boundary data) and Local accessibility (travel time)
			Mobility Model	MNL			
			Location Model	MNL			
			Development Model	MNL			
			Market Equilibrium	Optimization			
Gregor, 2007 (LUSDR)	Jackson County, Missouri	TAZ Level	Household model	MNL	Household, Firms, and Developer	--	Socio-demographic variables (household size, number of workers, age of household head), economic development variables (employment data), Local accessibility (Travel time)
			Employment establishment model	MNL			
			Development model	MNL			
Ettema et al., 2007 (PUMA)	The northern part of the Dutch Randstad	Grid Level	Household behavior model	MNL	Household, Firm, and Developer	--	Site variables (Land uses/densities, facilities), Local accessibility (accessibility levels, job availability)
			Market development model	MNL			
			Firm behavior model	MNL			
Paul et al., 2009 (G-LUM)	Texas	TAZ Level	Employment distribution model, residential development model,	Optimization formulation method, the entropy-based	--	N/A (5 years)	Socio-demographic variables (population), economic development variables (employment),

Study (Model)	Study Region	Spatial Resolution	Model components	Methods	Agents	Forecasted year (time between each prediction)	Independent Variables
			and land for employment and residential model	log-likelihood function			Regional accessibility (travel cost)
Pfaffenbichler et al., 2008 (MARS)	Chiang Mai city, Thailand	Grid Level	Household development model, Household location model, Employment location model, Transport Model	Casual loop diagram method	Households	--	Site variables (growth of residents), economic development variables (household income, car ownership, GDP)
Carr & Zwick, 2007 (LUCIS)	--	Grid Level	Agriculture suitability, natural feature suitability and development suitability	Raster GIS analysis	--	--	Agriculture variables (proximity to Ag. easements, Ag. security areas, Ag. land Cover and prime Ag soils), natural features (natural heritage Inventory (NHI) core habitat, NHI supporting landscapes, local natural areas, woodlands, interior woodlands, and steep slopes) and development suitability features (proximity to sewer service, water service, major roads, road density and intersection density)

Table 3 Variables Considered in Trip Based TDMs

Model Component	Variables	Trip Based Models				
		Southern California	Orlando	Chicago	Northwest FL	Gainesville
Trip Generation	Population	Yes	Yes	Yes	Yes	No
	Income	No	Yes	Yes	No	No
	Vehicle Ownership	No	No	No	Yes	No
	No. of HH	Yes	Yes	Yes	Yes	Yes
	Avg. Workers/HH	No	No	Yes	No	No
	Avg. Age/HH	No	No	Yes	No	No
	Employment	Yes	Yes	Yes	Yes	Yes
	School Enrollment	Yes	Yes	No	No	Yes
	Special Generators	No	Yes	No	Yes	Yes
	Hotel/Motel	No	No	No	Yes	No
Trip Distribution	Vehicle Ownership	Yes	No	No	No	No
	Income	No	No	Yes	No	No
	Employment	Yes	No	Yes	No	No
	Mix Density	Yes	No	No	No	No
Mode Choice	Income	No	No	Yes	No	No
	Vehicle ownership	No	No	No	Yes	No

Table 4 Variables Considered in Activity Based TDMs

Zonal Variables	Activity Based Models			
	Southeast FL	Northeast FL	Tampa Bay	Treasure Coast
Population	Yes	No	Yes	No
Vehicle Ownership	No	No	Yes	No
No. of HH	Yes	Yes	Yes	No
Employment	Yes	Yes	Yes	Yes
School Enrollment	Yes	Yes	Yes	Yes
Special Generators	No	Yes	Yes	No
Hotel/Motel	Yes	No	Yes	No
Shopping Center Density	Yes	No	No	No
Recreational Area	Yes	No	No	No
Parking Fee	No	Yes	No	No

Table 5 Variables Considered in Disaggregate Level Studies

Studies	Study Region	Dependent Variables (resolution)	Variable Group		
			Socio-Demographics	**Land Use Variables**	**Economic Development**
Bhat and Eluru, 2009	San Francisco	VMT (Household)	Age, number of children and full-time students, vehicle ownership level	Bike lane density, accessibility to shopping centers	Number of workers in HH
Cervero and Murakami, 2010	370 urbanized areas in the US	VMT/Capita (Urban area)	Population density	Roadway density, railway density, accessibility to job,	Employment density, retail employment density
Boarnet and Crane, 2001	San Diego	No. of auto trips (Individual)	Age, gender, race, education, number of children, vehicle ownership level	--	Number of workers in HH
Cao et al., 2009	Northern California	Home-based nonwork trips (household)	Age, education, number of children, vehicle ownership,	Institutional business density	Income, number of workers, number of business centers
Park et al. 2015	31 regions in the US	Binary variable: Intrazonal/Interzonal Travel (Trip)	Population density at the TAZ	Accessibility to jobs at the TAZ	Employment, population-employment balance at the TAZ
Cervero, 2002	Montgomery County, Maryland	Mode Choice (Individual)	Vehicle ownership level	Land use diversity, accessibility to job, ratio of sidewalk	Employment density, household income
Cheng et al., 2019	Nanjing, China	Mode Choice (Individual)	Age, gender, education, presence of child, vehicle ownership level	Roadway density, metro station density, bus station and network density	Income

3 STAKEHOLDERS SURVEY

The research team conducted a stakeholder survey to obtain input on the different variables currently considered in the travel demand models. The detailed survey questionnaire, data compiled and important insights from the analysis are discussed in this section.

3.1 Survey Questionnaire Development and Deployment Procedure

This online survey is designed to collect FDOT stakeholder responses on initial model framework in the Qualtrics platform. The main focus of this survey is to identify important input variables for Travel Demand Models (TDMs). The survey beings with an informed consent statement as required under IRB protocols followed by the survey questionnaire. The survey consent form is provided in the Appendix 2. The main survey questionnaire consists of two parts. The first part elicits survey responses on variable group relative importance while the second part is focused on identifying the exact variables of interest in each variable group. A brief discussion of the two parts of the survey follows:

3.1.1 Relative importance by variable group

In this part of the survey, the respondents will be asked to assign relative weights between the variable group pairs (e.g., socio-demographics vs land use). We first request the respondents to assign relative weights across variable groups. The relative importance procedure is illustrated with an example to assist the respondents' decision process. The process begins with the relative importance of socio-demographic variables compared to land use variables and economic development variables. Then, the respondents will be requested to assign a relative weight for land use variables compared to economic development variables.

The questions considered are listed below:

(a) Provide a relative score for "socio-demographic variables" (between 1/9 and 9) compared to land use and economic development variables.

(b) Provide a relative score for "land use variables" (between 1/9 and 9) compared to economic development variables.

3.1.2 Variable selection by variable group

<u>In the second part of the survey</u>, we request respondents to identify important variables (including must have variables) in each group (e.g., population and vehicle ownership) (see the full survey in Appendix 3). The survey will provide respondents with a list of socio-demographic, land use and economic development variables. From this list, the respondents will be requested to select a subset of variables as important. Among the selected important variables, we further request them to identify the must have variables for the proposed framework. For example, the questions for socio-demographic variables are listed below:

(a) Please choose important **<u>socio-demographic variables</u>** from the following list (select all that apply):

i) Population
ii) Number of Households
iii) Age distribution
iv) Gender distribution
v) Race

vi) Number of children
vii) School Enrollment
viii) Educational Status
ix) Vehicle Ownership
x) Other (please specify)

(b) Please choose **<u>must-have socio-demographic variables</u>** from the important variables you selected in the following list[1] (select all that apply):
i) Population
ii) Number of households
iii) Age distribution
iv) Vehicle ownership
v) Other (please specify)

<u>The survey is wrapped up with a brief set of questions on respondent employment experience</u>. The specific questions are listed below:

(a) What sector are you employed in?
i) Public Sector
ii) Private Sector

(b) Which of these agencies do you work for[2]?
i) Florida Department of Transportation (FDOT)
ii) Metropolitan Planning Organization (MPO)
iii) Metropolitan Transportation Plan (MTP)
iv) Central Florida Expressway Authority (CFX)
v) Miami-Dade Expressway Authority (MDX)
vi) Tampa Hillsborough Expressway Authority (THEA)
vii) Other (please specify)

(c) Please specify the agency you work for[3]:
(d) How long have you been in the transportation industry?
i) Less than 2 years
ii) 2-5 years
iii) 5-10 years
iv) More than 10 years

[1] Options will be based on answer to question a e.g., "other (please specify)" option will be available if respondents choose that option in question a.
[2] This question is only for public sector employees.
[3] This question is only for private sector employees.

3.2 UCF IRB Procedure

Any study involving human subjects research conducted at UCF needs to be reviewed and approved by UCF IRB to comply with federal regulations for human subject protection. Approval must be obtained prior to including human participants in an investigation. When reviewing research, the IRB considers several issues e.g., the process for recruitment, selection and informed consent of prospective research participants and assessment of the risks and potential benefits to participants. For completing the application, we submitted a consent form, the study protocol, recruitment material, and survey document. The application has been reviewed and approved as a "Human Research" that is exempt from IRB Review according to the federal regulations (please see Appendix 1).

3.3 Methodology

In this section, we will discuss the methodology employed for analyzing the survey data. As discussed earlier, we mainly collect two sets of responses on the variables considered in this research: relative weights between variable group pairs and selection of important variables in each group. By averaging the relative weights across the responses, we will prepare a weight matrix (or importance/priority matrix) for the variable groups i.e., a 3×3 matrix. Using the weight matrix, we will be able to determine an overall importance score for each variable group. The result will guide us to identify the most important variable group suggested by the practitioners. From the second group of questions (important variable selection), we will identify the important and must have socio-demographic, land use and economic development variables. In consultation with project manager, we will use the responses to select the variables for the proposed model framework. In the following section, we will discuss the pairwise weight matrix in context of this study.

3.3.1 Pairwise Comparison Method

In this study, we followed pairwise comparison method for determining weights of the variable groups. In this approach, we compare variable group A with variable group B on a reciprocal numerical rating scale ranging from 1/9 (extreme preference for group B) to 9 (extreme preference for group A). The numerical scale for preference rating is given below in Table 6.

Table 6 Preference Rating Point Table

Preference rating	Definition
1	Equal importance
2	Weak or slightly important
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very, very strong
9	Extreme importance

Source: T.L. Saaty (2008)[4]

[4] Saaty, T.L. (2008). Decision making with the analytic hierarchy process. Int. J. Services Sciences, 1(1).

To illustrate the use of the process from Table 1, consider the following example. Between group A (e.g., socio-demographics) and group B (e.g., land use), an individual provides moderate importance to group A. In that case the rating for A versus B will be scored as 3. Once a ranking for A versus B is available, the ranking for B versus A is simply computed as it's reciprocal (1/3). An example of pairwise relationships for three variable groups is provided in Table 7.

Table 7 Pairwise Comparison Matrix

Variable Group	**Socio-demographics**	**Land Use**	**Economic Development**
Socio-demographics	1	3	4
Land Use	1/3	1	2
Economic Development	1/4	1/2	1

The ranking of the variable groups can be computed from the pairwise comparison matrix. First, elements of each column are normalized by sum of the column (See Table 3). Then elements of each row are summed to get priority column. Elements of priority column are ranked at the last step (see Table 8 column 5 and 6).

Table 8 Determining Ranking from Pairwise Comparison Matrix

Variable Group	**Socio-demographics**	**Land Use**	**Economic Development**	**Priority**	**Ranking**
Socio-demographics	0.63	0.67	0.57	1.87	1
Land Use	0.21	0.22	0.29	0.72	2
Economic Development	0.16	0.11	0.14	0.41	3

From the above example, we can conclude that the individual thinks socio-demographic variable group as the most important and economic development variable group the least important. In case of multiple responses, we will first take the average of weights for each pair and then construct the weight matrix as discussed above.

3.4 Analysis and Results

3.4.1 Weighing of the Variable Groups

To weigh the variable groups, a pairwise comparison method is adopted in this study. To get FDOT stakeholder's assigned values, a survey was performed asking for FDOT officials' judgmental weights for the groups in pairs on a scale of 1/9 to 9. A total of 22 fully completed responses were collected and average values of the pairwise weights were taken for computing the final ranking. Average pairwise weights of different groups are presented in following Table 9.

Table 9 Pairwise Comparison of Variable Groups Based on Survey

Variable Groups	**Socio-demographic**	**Land use**	**Economic development**
Socio-demographic	1.00	3.29	4.00
Land use	0.30	1.00	3.96
Economic development	0.25	0.25	1.00

Weights of the variable groups can be computed from the pairwise comparison matrix. First, elements of each column are normalized by sum of the column (see Table 6). Then elements of each row are summed to get weight or priority column. Elements of priority column are ranked at the last step (see Table 10 column 5 and 6).

Table 10 Determining Ranking from Pairwise Comparison Matrix

Variable Groups	**Socio-demographic**	**Land use**	**Economic development**	**Priority**	**Ranking**
Socio-demographic	0.64	0.72	0.45	1.81	1
Land use	0.20	0.22	0.44	0.86	2
Economic development	0.16	0.06	0.11	0.33	3

From the ranking of the variable groups, we found that socio-demographic variables are the most important and economic development variables are the least important variable groups suggested by the stakeholders.

3.4.2 Important and Must-have Variables

In the next step of our analysis, we identify the important socio-demographic, land use and economic development variables analyzing the responses from the FDOT stakeholders. In addition, we determine the must-have variables among the important variables. For selecting important and must-have variables, we consider how many times a variable was selected as important and must-have variable by the respondents.

3.4.2.1 Socio-demographic Variables

The number of times a socio-demographic variable is chosen as an important and must-have variable is presented in Figure 1. From Figure 1, it is evident that population, number of households, age distribution, number of children, school enrollment, educational attainment and household vehicle ownership level are mainly chosen as the important socio-demographic variables. Among these important variables, population, number of households, age distribution and household vehicle ownership level are mostly chosen as must-have socio-demographic variables for the proposed model framework. Among other variables, a small sample of the respondents (6 to be precise) specified other variables such as employment status, employment type, long term visitors and income as important variables.

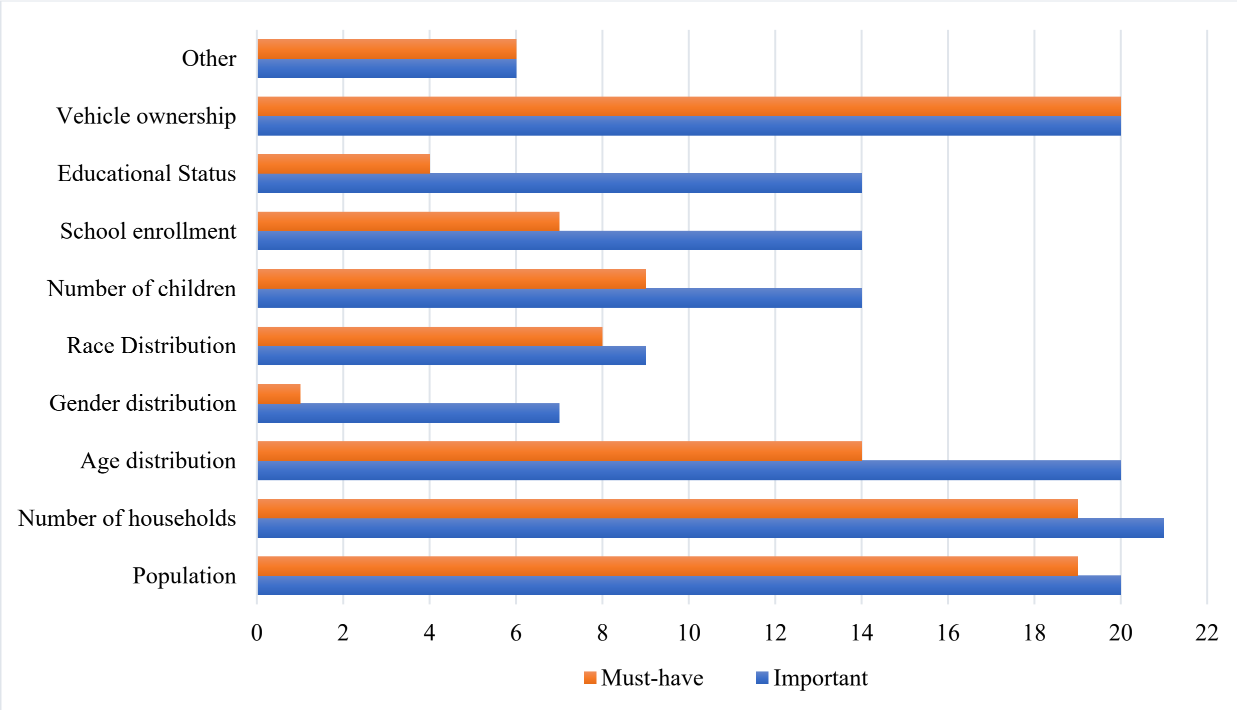


Figure 1 Number of times selected as important and must-have sociodemographic variable

3.4.2.2 Land Use Variables

The number of times a land use variable is chosen as an important and must-have variable is presented in Figure 2. From Figure 2, it is evident that land use mix, residential area, business center density, institutional area, roadway density, bus station/network density, accessibility to jobs and number of hotel/motels are mainly chosen as the important land use variables. Among these important variables, land use mix, residential area, business center density, accessibility to jobs and number of hotel/motels are mostly chosen as must-have land use variables for the proposed model framework. Among other variables, the respondents specified recreational area, entertainment area, parking, walkability index, land use plan designation, transit-oriented developments, accessibility to multimodal systems, core employment versus core residential connectivity and undevelopable land as important variables.

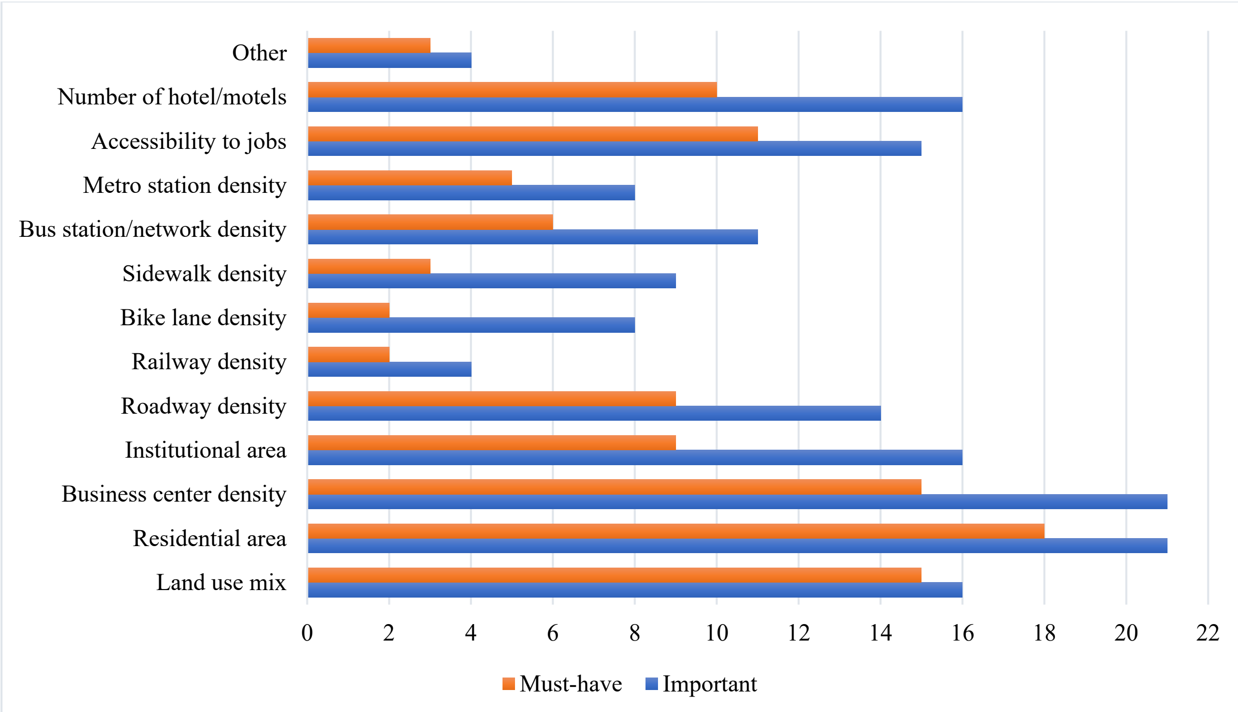


Figure 2 Number of times selected as important and must-have land use variable

3.4.2.3 Economic Development Variables

The number of times an economic development variable is chosen as an important and must-have variable is presented in Figure 3. From Figure 3, it is evident that all the proposed variables including median income, employment, retail employment density, population-employment balance, number of workers per household, retail density and shopping center density are chosen as important economic development variables. Among these variables, median income, employment, and number of workers are mostly chosen as must-have economic variables for the proposed model framework. Among other variables, the respondents specified include population vs. employment growth index for each zone/area type, multimodal integration for better accessibility to employment, demand management integration for congestion mitigation improving regional access, regional connection of metropolitan areas and jobs by NAICS category as important variables.

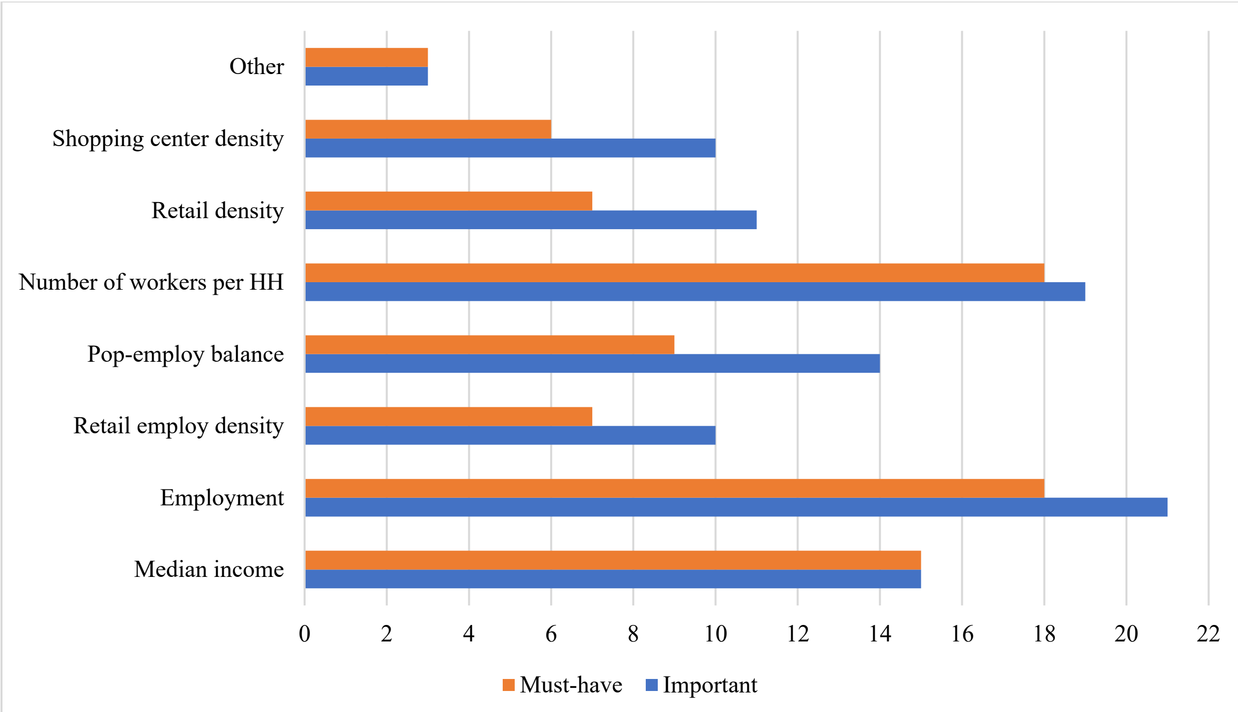


Figure 3 Number of times selected as important and must-have economic development variable

3.4.3 Recommendations

The survey analysis presented in the previous section allows us to conclude that the initial set of variables considered by the research team incorporate a majority of the must have variables for an integrated socio-demographic, land use and economic development framework. The analysis highlighted the relative importance of the three variable groups with the respondent placing the highest emphasis on socio-demographic variables and least emphasis on economic development variables. The reader would note that the respondents have suggested multiple additional variables. From the suggestions made by survey respondents, the following variables by variable groups are potentially useful suggestions: (a) socio-demographics: employment status, employment type and long-term visitors, (b) land use: recreational area, parking, walkability, and undevelopable land and (c) economic development: population growth vs employment growth and jobs by NAICS category.

The research team considered these variables carefully and have arrived at the following recommendations. The research team will be able to provide land use variables for recreational and undevelopable area using the parcel level data in a useful way. Employment numbers from census data will be generated for a spatial zone but it will not be feasible to provide employment at a household level as we are not generating household level data. We will try to obtain employment numbers by employment type (or NAICS code) at an appropriate spatial resolution based on data availability. Further, given population growth and employment growth are considered in our analysis, the relative ratio can be computed. Finally, variables such as parking are very hard to obtain on a statewide basis. The research team hopes the users can generate surrogate measures based on land use type distributions to be included in the data.

4 VARIABLES CONSIDERED FOR FORECASTING

In this research, we prepared sociodemographic, land use and economic development variables important for transportation planning models. In deliverable 4 and 5, we provided detailed description of variables to be considered for our model framework. For sociodemographic and economic development variables, we consider publicly available data sources such as U.S. Census Bureau, Bureau of Economic Analysis, American Community Survey, and identified all of the variables at the desired spatial resolutions. For land use variables, we mainly consider parcel level data sourced from Florida Department of Revenue (FDOR). The list of variables selected for forecasting from each of the three variable groups was finalized based on stakeholder survey response feedback, data availability and discussions with FDOT personnel (see Table 11). We also consider other data sources for generating independent and control variables such as the Federal Emergency Management Agency (flood zone variables), Florida Natural Areas Inventory (Florida conservation lands), and Bureau of Economic and Business Research (control variable for population).

Table 11 List of Selected Variables and Data Sources

Variable Group	Variables	Data Sources
Sociodemographic variables	Population, number of households, vehicle ownership level, race distribution	U.S. Census Bureau and American Community Survey
Land use variables	Land use type, percentage of different land use types, land use mix/land use diversity variable	Florida Department of Revenue and Florida Geographic Data Library
Economic development variables	Number of Jobs, number of jobs by industry, number of business and median income	U.S. Census Bureau, American Community Survey and Bureau of Economic Analysis

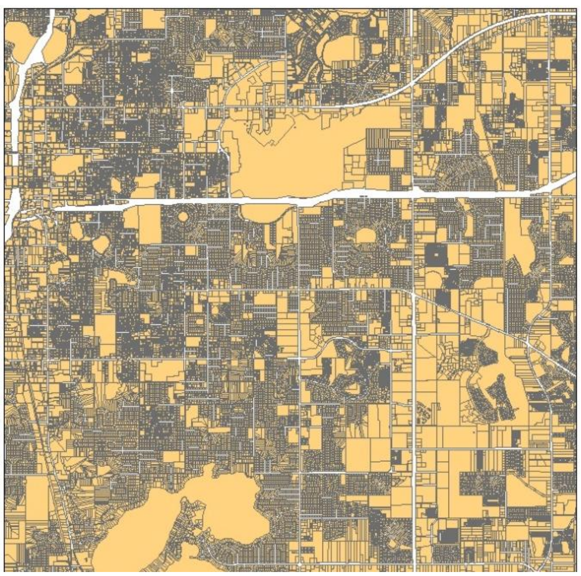
5 BASE YEAR DATA PREPARATION

In this section, we discuss the steps followed in base year data processing. In the first step, we processed statewide parcel level land use data. In the second step, we processed the remaining variables from different data sources. For GIS shapefile data (e.g., roadway and pedestrian data), variables are processed using geoprocessing tools in ArcGIS. In the following subsections, data processing procedures are discussed.

5.1 Parcel Data Preparation

5.1.1 County Parcel Shapefile

To identify land use of individual parcels, parcel data for the base year obtained from Florida Department of Revenue (FDOR) were utilized (https://floridarevenue.com/property/Pages/DataPortal_RequestAssessmentRollGISData.aspx). County parcel shapefile contains unique parcels within each county that indicated by unique 'Parcel No'. At the first step of parcel data preparation, we check possible repetitions of the same parcel (duplicate parcels) in the shapefiles. Duplicate parcels refer multiple parcels with same location (latitude and longitude) and land area. Presence of such duplicate parcels may result in inaccurate results. Therefore, we run an algorithm using GeoPandas package in Python to remove duplicate parcels and only retain the primary parcels.



Table

orange_2020pin

FID	Shape *	PARCELNO
0	Polygon	332401000000004
1	Polygon	332401000000003
2	Polygon	342229000000003
3	Polygon	342229000000005
4	Polygon	342229000000001
5	Polygon	342335000000001
6	Polygon	342428000000001
7	Polygon	342425000000001
8	Polygon	342421000000004
9	Polygon	342421000000005
10	Polygon	342420000000003

Figure 4 Parcel Shapefile and Attribute Table

5.1.2 Parcel Data Layer Preparation

The Name-Address-Legal (NAL) file for the base year is used together with parcel level county shapefile to get the property information. NAL file has unique parcel ID with equivalent parcel level attribute information such as property/feature value, land value, land area in square feet, land use codes (DOR_UC), owner name, owner address, physical address, physical zip code, building details and so on.

parcel_id	asmnt_yr	bas_strt	atv_strt	grp_no	dor_uc
012527000000100000	2020.00000	03	8	3	057
012527000000120000	2020.00000	05	8	5	010
012527000000140000	2020.00000	10			094
012527000000150000	2020.00000	05	8	5	010
012527000000160000	2020.00000	10			091
012527000000170000	2020.00000	05	8	5	010
012527000000200000	2020.00000	10			094
012527000000210000	2020.00000	05	8	5	010
012527000000230000	2020.00000				094
012527000000300000	2020.00000	10			094
012527000000310000	2020.00000	05	8	1	010
012527000000350000	2020.00000	05	8	5	010
012527000000400000	2020.00000	03	8	1	057
012527000000450000	2020.00000	06	6	4	035
012527000000500000	2020.00000	10			094

Figure 5 Name-Address-Legal (NAL) File

5.1.3 Joining Shapefiles and NAL files

In the next step, we combine the data for all 67 counties into a single file and join NAL file variables with shapefile data. After data cleaning, final parcel data consists of 9.16 million records. In the next step of the analysis, we identify the land use type for each individual parcel using the DOR_UC code provided in NAL file. DOR_UC code for different land use categories is provided in the Table 12. We summarize the overall procedure for land use data processing in Figure 6.

Table 12 Land Use Category Based on DOR Land Use Codes

Land Use Type	**DOR_UC Code**
Agricultural	50-69
Industrial	41-49
Vacant Industrial	40
Institutional	71-79, 81, 84
Vacant Institutional	70
Single-Family Residential	1
Multi-Family Residential	3, 8
Other Residential	2, 4-7, 9
Vacant Residential	0
Public	83, 85-91
Vacant Public	80
Recreational	82, 97
Retail or office	11-39
Vacant Retail or office	10
Others	92-96, 98-100, 995, 999

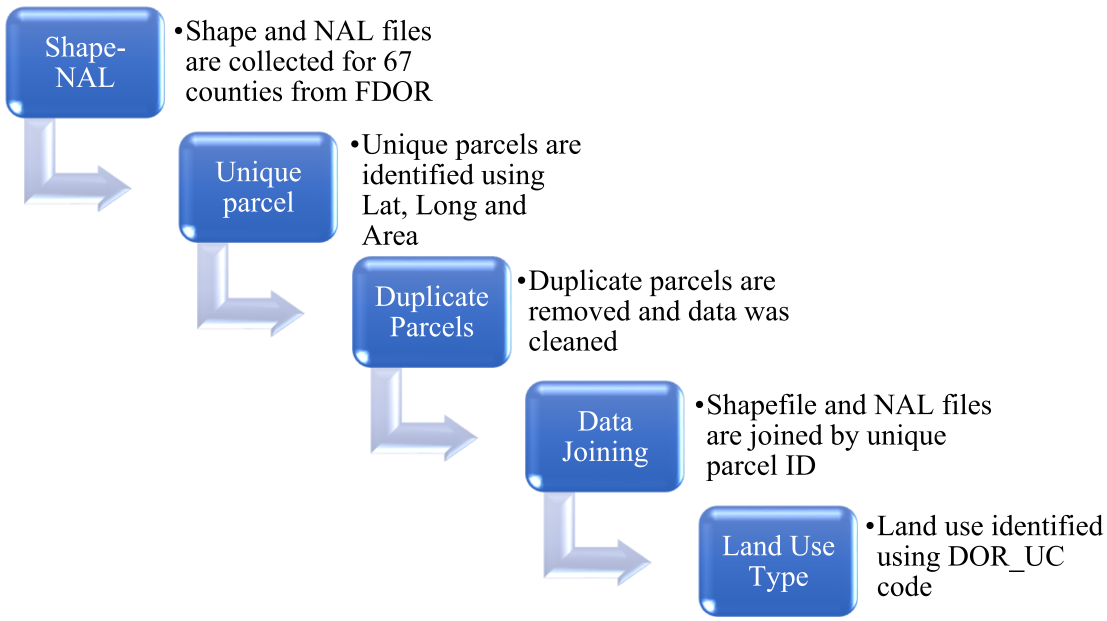


Figure 6 Parcel Data Processing Algorithm

5.1.4 BG Level Land Use Distribution

To identify block group level land use patterns, we employ geoprocessing tools in ArcGIS to intersect parcel shapefiles with block group shapefile. From the intersection result, we are able to identify the location of the parcels within a block group. However, we first repair geometry of the individual parcel shapefiles to remove any parcels without any geometry. Such parcels do not allow us to perform the intersection operation. Then, intersected land area is aggregated by the block group and land use type. Finally, we estimate percentage of different land use types (e.g., single family residential, multi-family residential, retail/office) for each block group in the state of Florida. The toolbox employed to process geospatial data in ArcGIS is illustrated in Figure 7.

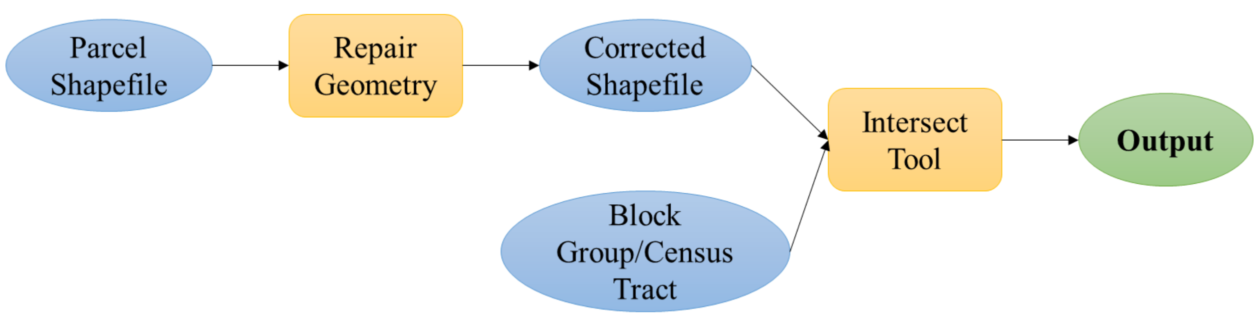


Figure 7 Land Use Data Processing at the BG/CT Level

5.1.5 Processing of Other LU Variables

Remaining land use variables are processed from shapefiles collected from FDOT Roadway Characteristics Inventory and Florida Geographic Data Library. Shapefiles for different variables e.g., bike-lane length are intersected with block group and then intersected lengths are aggregated at the block group level. In this process, we prepared several land use variables including road, sidewalk, and bike-lane length (density), number of bus stops and bus route density. However, it is important to note that we currently do not have transit data (bus stop and bus route) for multiple years. In absence of historical data, these two variables might not be included in the model framework. We will consult the data management agencies to see if these GIS layers are available for all years (2011-2020).

5.1.6 Florida Conservation Area

In this research, we identify the parcels located in Florida conservation areas using GIS data sourced from Florida Natural Areas Inventory (FLMA). The results indicate that 28.21% of area in Florida is natural conservation land. We recognize that land use of these parcels is unlikely to change over time. Therefore, these parcels will have same land use classification for the future years. Florida conservation areas are presented in Figure 8.

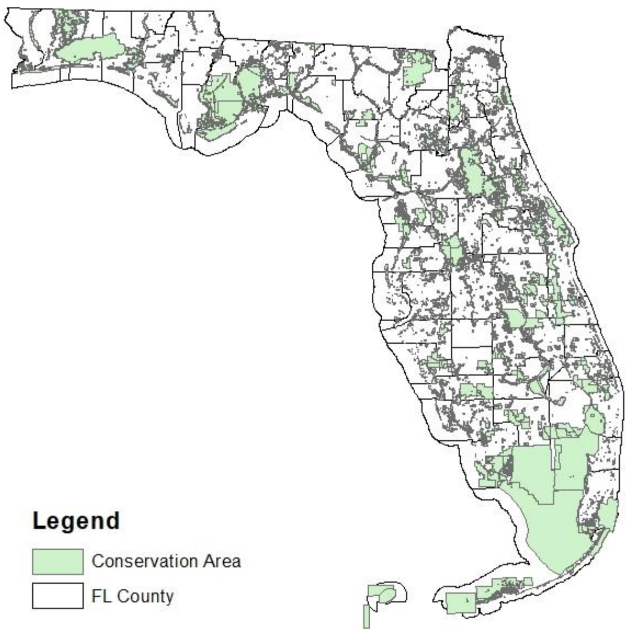


Figure 8 Florida Conservation Area (Source: FLMA)

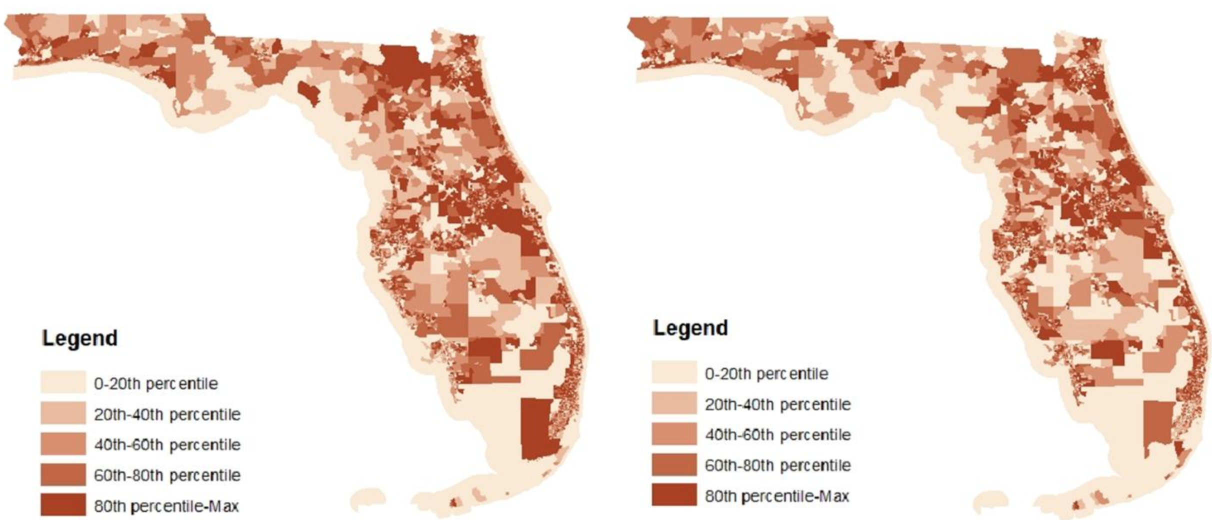
5.2 Data Consistency Analysis

In this section, we examine the consistency of the variables by comparing them at different spatial resolutions. For example, census tracts with higher population are likely to have higher number of households and residential parcels. If we see a similar pattern for these three variables, we can conclude that the variables are consistent. In this report, we compare such consistencies for selected variable groups. We begin our comparison with state level demographic data comparing population with households, employment, and residential parcels. The results are presented in Table 13. The results highlight expected relationships in terms of household size and employment at the household level.

Table 13 Summary of the Selected Variables (Total Households 7.93 million)

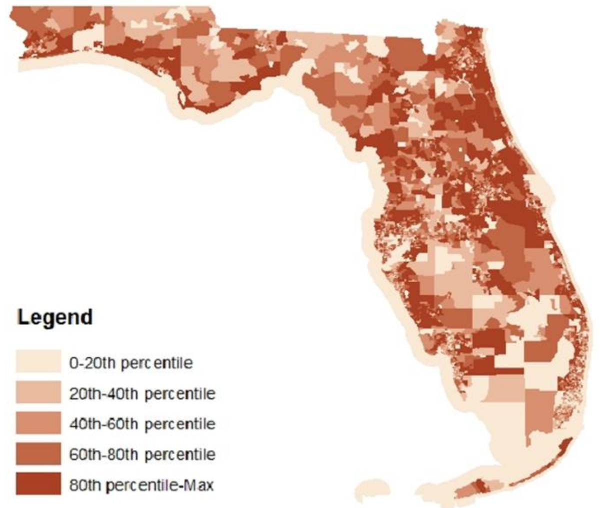
Variables	Total Count (in million)	Per Household
Population	21.22	2.68
Number of Jobs	6.62	0.83
Number of Residential Parcels (Single-family, Multi-family and Other Residential)	6.54	0.82

In subsequent analysis, we undertake the consistency analysis at more disaggregate resolution using external data to identify the accuracy of the processed variables (e.g., agricultural area vs. agricultural products at the county level). The results of the analysis are presented from Figures 9 through Figure 11. In Figure 9, we compare census tract population with number of households and number of residential parcels (including single family residential, multi-family residential and other residential). From the figure, it is evident that these three measures are consistent across the state. Similarly, county level population and number of jobs are presented in Figure 10. From Figure it is clear that the distributions are similar across the state. In addition, we compare county level agricultural land area with agricultural products (in million USD) and the summary is presented in Figure 11. Agricultural revenue data is sourced from Florida Department of Agriculture & Consumer Services (https://www.fdacs.gov/Agriculture-Industry). From the figure, it is found that revenue from agricultural products is higher mostly in the counties with increased agricultural land area. From the data, we observed that Palm Beach County is ranked first in the state of Florida in terms of both agricultural land area and agriculture product revenue. Therefore, from our analysis, we can conclude that the processed variables are consistent.



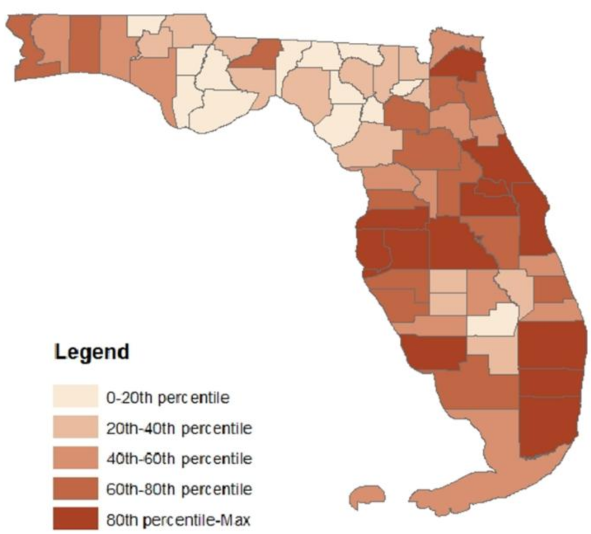
(a) Census tract population

(b) Census tract households

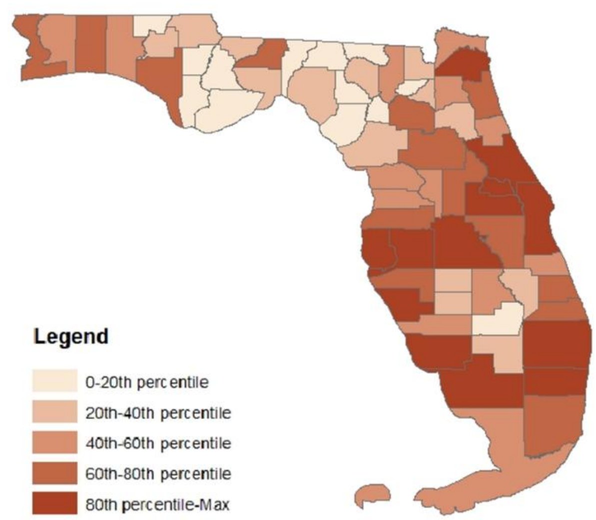


(c) Census tract residential parcel count

Figure 9 Comparison between Population, Number of Households and Residential Parcel

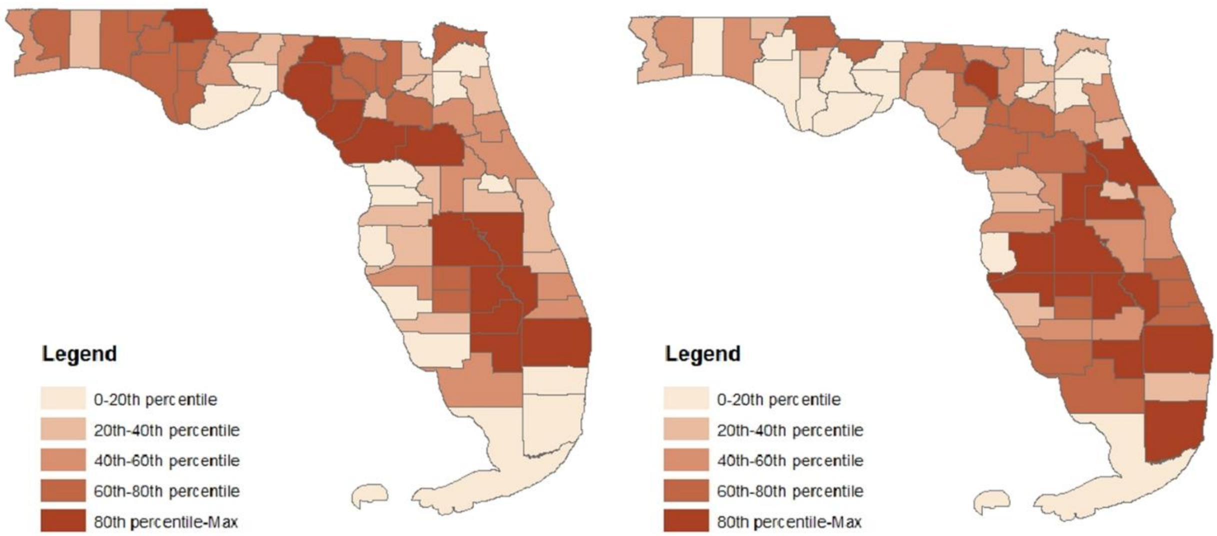


(a) County level population



(b) County level jobs

Figure 10 Comparison between County Population and Number of Jobs



(a) County level agricultural area (b) County level agricultural product in million USD

Figure 11 Comparison between Agricultural Area and Agricultural Product

6 MODEL FRAMEWORK AND ECONOMETRIC METHODOLOGY

In this section, we provide details of the model framework employed for variable generation and present the econometric model details.

6.1 Model Framework

In this section, we describe the developed model framework by variable group and econometric methodology considered for different model components. In Table 14, we summarize methodological approaches and forecasting procedures employed for the three variable groups. From the table, it is evident that we employed a wide range of methods for predicting future scenarios including linear regression model, MNL based fraction split model, multinomial or binary logit model and conversion factors. For socio-demographic and economic development variables, we generate predictions directly from the model framework. For land use model components, we employ a microsimulation technique to translate the probabilities into discrete outcomes. For more detailed discussion on the various model components, the readers can review deliverable 5.

6.1.1 Socio-demographic Variables

The sociodemographic variables considered for forecasting include population, number of households, vehicle ownership level and race distribution. The different variables are modeled as
(a) change across the years (population),
(b) proportion by share (vehicle ownership and race distribution) and

For spatial resolution, two of the variables are analyzed at the block group resolution (population and race distribution) and the remaining variables are analyzed at the census tract resolution (vehicle ownership and number of households). In terms of methods considered, we employ linear regression for population while fractional split approach is considered for vehicle ownership share and race/ethnicity distribution. Finally, the number of households is predicted using population estimate and a conversion factor identified from the observed data. The models are developed using variable changes from the previous year as appropriate for each variable of interest.

6.1.2 Land Use Variables

The land use variables to be forecasted include land use type (parcel resolution), percentage of different land use types, and land use mix/land use variables (block group, census tract and county resolution). The land use data forecasting exercise is undertaken at the parcel resolution. The land use forecasting process is conducted separately by current land use type.

Based on the land use distributions, we used the following land use types in our analysis:
(1) Agricultural
(2) Commercial
(3) Industrial
(4) Institutional
(5) Mixed use
(6) Multi-family residential
(7) Office
(8) Other residential
(9) Others
(10) Public
(11) Recreational
(12) Single-family residential
(13) Vacant commercial
(14) Vacant industrial
(15) Vacant institutional
(16) Vacant public
(17) Vacant residential, and
(18) Water

Post forecasting, the data from all land use component forecasts are aggregated at the appropriate resolution for their inclusion in other modules as necessary.

Table 14 Modeling Approaches and Forecasting Procedure

Variable (Resolution)	Dependent Variable	Method	Forecasting Approach
Socio-demographic Variables			
Population (Block Group)	Population changes between consecutive years (y)	Linear regression model	$y = \beta X$ where, β is a set of estimated coefficients and X is a set of independent variables
Number of Households (Census Tract)	Number of households in a given year (y)	Conversion factor	$y = Population/F$ Where, F is estimated to be 2.68
Vehicle Ownership (Census Tract)	Fraction of households with 0,1,2,3+ vehicles (R)	MNL based fractional split model	$R_{itr} = \frac{exp\{\beta_r d_{itr}\}}{\sum_{j=1}^{4} exp\{\beta_r d_{itr}\}}$ where, β_r is a set of coefficients for alternative, r and d_{itr} is independent variables for block group i, year, t and alternative, r
Race Distribution (Block Group)	Fraction of people having race/ethnicity: White alone, Black/African American, Hispanic, Asian and Other (R)	MNL based fractional split model	$R_{itr} = \frac{exp\{\beta_r d_{itr}\}}{\sum_{j=1}^{5} exp\{\beta_r d_{itr}\}}$
Land Use Variables			
Change Vs. No Change (Parcel)	Dichotomous variable: change vs no change ($y \in 0,1$)	Binary Logit Model	Microsimulation approach (see Section 4 for details)
Partial Vs. Full Conversion	Dichotomous variable: partial vs full ($y \in 0,1$)	Binary Logit Model	Microsimulation approach (see Section 4 for details)
Fraction of Change	Fraction of area changes given a partial conversion (R)	Binary logit based fractional split model	$R_{itr} = \frac{exp\{\beta_r d_{itr}\}}{\sum_{j=1}^{2} exp\{\beta_r d_{itr}\}}$
New Land Use Type	Land use category of the area that changed its land use ($y \in 0,1,..,N$)	Multinomial logit model	Microsimulation approach (see Section 4 for details)
Economic Development Variables			
Number of Jobs (County)	Number of jobs in thousand (y)	Linear regression model	$y = \beta X$ where, β is a set of estimated coefficients and X is a set of independent variables
Number of Jobs by Industry (County)	Fraction of total jobs by different industry classification (R)	MNL based fractional split model	$R_{itr} = \frac{exp\{\beta_r d_{itr}\}}{\sum_{j=1}^{9} exp\{\beta_r d_{itr}\}}$
Number of Businesses (County)	Number of businesses (y)	Conversion factor	$y = Number\ of\ jobs/F$ Where, F is estimated to be 12.88
Median Income (County)	Median Income in thousand (y)	Linear regression model	$y = \beta X$ where, β is a set of estimated coefficients and X is a set of independent variables

The land use model evolution process is considered as four decision annual process. First, every parcel is checked for change (Yes/No). If the parcel is not selected for change, we retain the parcel without any change. If the parcel is selected to change, based on the observed distribution, we examine if the parcel will change completely or partially. If the parcel is selected for a complete change, then we process the parcel to identify the new land-use type for the parcel. If the parcel is selected for a partial change, we need to identify the proportion of the parcel that's changing. Once this percentage is determined, the partial parcel's new land-use will be determined. The overall land use model process is demonstrated in Figure 12. The first component of the framework is a binary logit model that identifies whether land use of a parcel changes or not between year *t* and *t-1*. For parcels with no change, no further analysis is necessary. For parcels selected for change, another binary logit model identifies the type of change defined as whether land use of a parcel completely converts into another land use type, or a fraction of a parcel converts to a different land use. For fully converted parcels, we estimate a multinominal logit (MNL) model to identify the new land use type. For partially converted/developed parcels, we estimate a binary fractional split model to identify the fraction of unchanged land use and new land use. The new land use type (for partially converted parcels) is determined based on the estimated MNL model. The independent variables considered in these models are processed using data from the previous year.

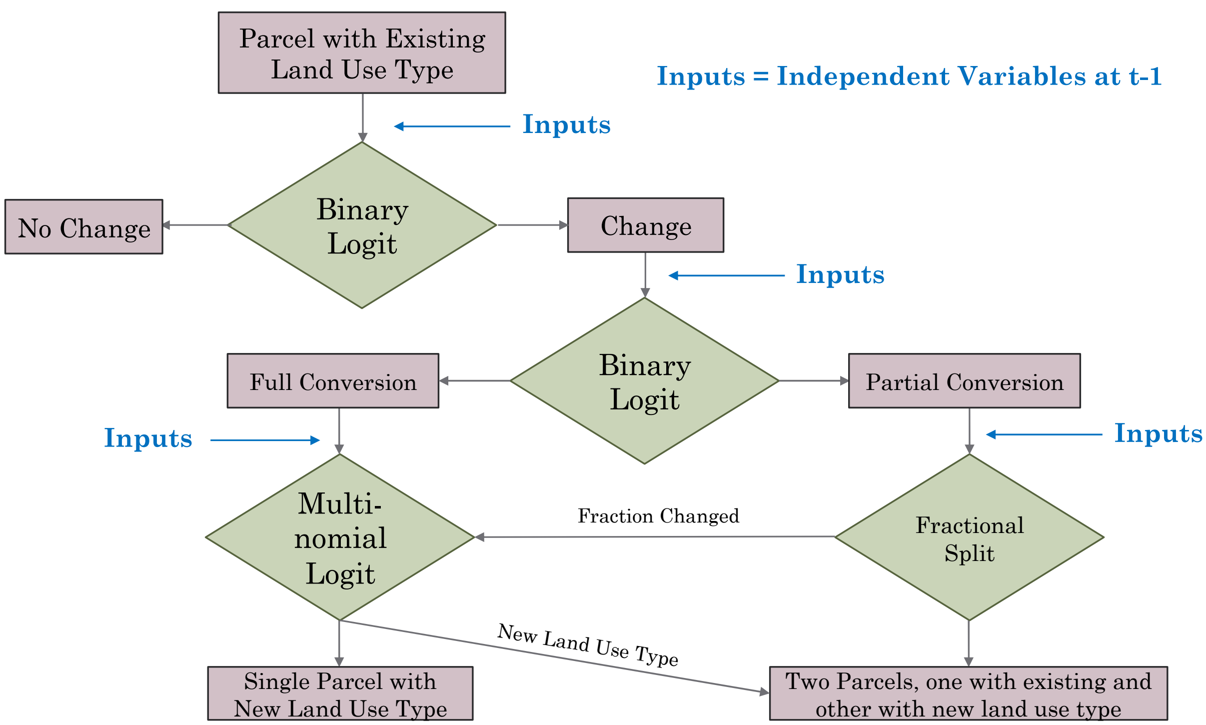


Figure 12 Land Use Model Framework

To illustrate the overall decision process, we provide an example of the possible outcomes in the following year for a parcel. Land use of the parcel is assumed to be vacant residential in year t. For the following year (t+1), there can be three possible outcomes. For example, we may get either of two outcomes from first binary logit component: no change and change. *Outcome 1: if model suggests no change, the parcel retains its existing land use (vacant residential).* If model suggests a change, second binary logit component will suggest either of two outcomes: full conversion or partial conversion. *Outcome 2: if it is full conversion, there will be one parcel with same geometry* *but with a new land use suggested by the MNL model (e.g., multi-family residential). Outcome 3: if it is partial conversion, there will be two new parcels, one with existing land use (vacant residential) and another with a new land use (e.g., multi-family residential).* Now, area distribution between two new parcels will be determined by an intermediate fractional split model. The overall process is demonstrated in Figure 2. In the following subsection, we describe the estimated land use models for single family residential parcels.

It is important to recognize that the land use model framework identified above is customized by current land-use of the parcel. Thus, the model system presented in Figure 12 (or 13) is repeated by 18 land use types including agricultural, commercial, industrial, institutional, mixed use, multi-family residential, office, other residential, others, public, recreational, single-family residential, vacant commercial, vacant industrial, vacant institutional, vacant public, vacant residential, and water. In the following subsection, we present and discuss the estimated model components for single-family residential parcels. The model components for other land use categories are presented in the Appendix.

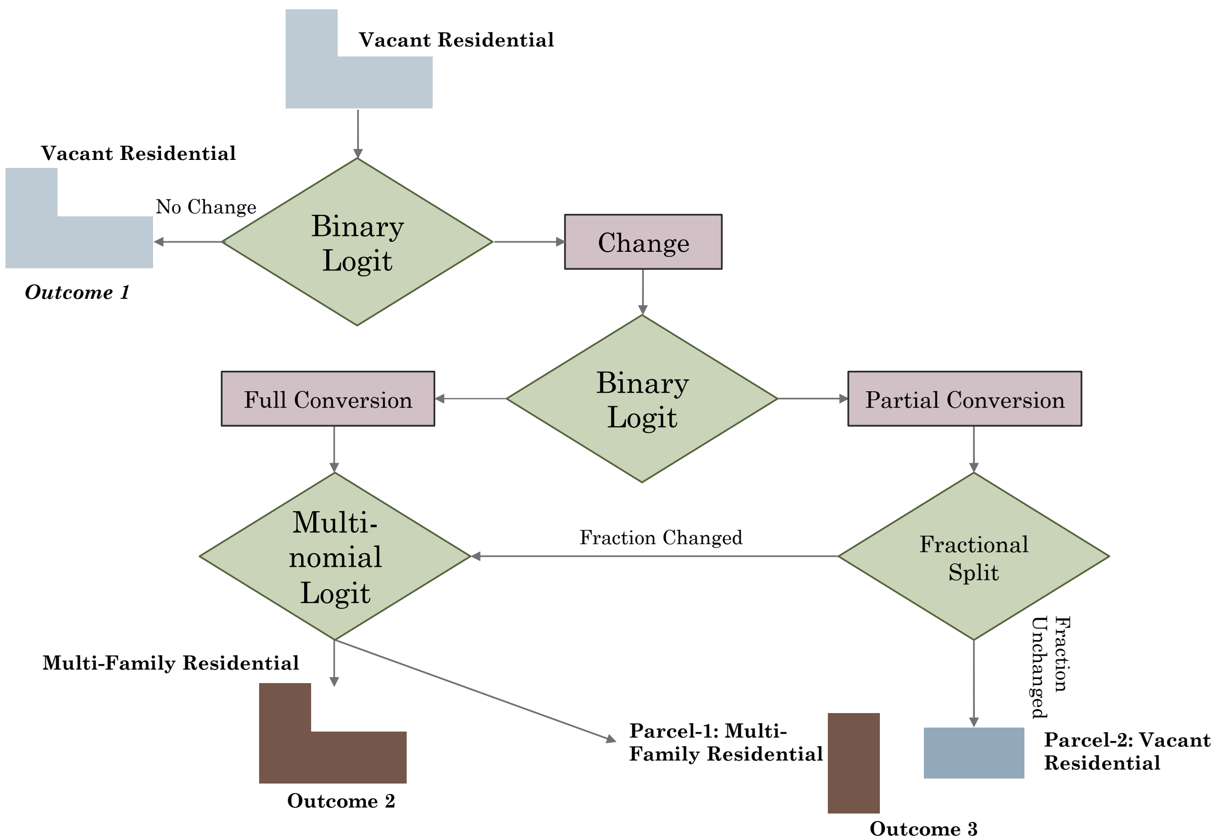


Figure 13 An Example of Possible Model Outcomes

6.1.3 Economic Development Variables

Economic development variables considered include number of jobs, number of jobs by industry, number of businesses and median income. Among the variables, number of jobs and median income are modelled using linear regression model while number of jobs by industry is modelled using MNL fractional split model. As we observed a very strong correlation between number of jobs and number of businesses, we employ a conversion factor for estimating number of businesses. Independent variables for these models are processed from parcel level land use data, sociodemographic and economic development variables from the previous year.

6.2 Econometric Methodology

Econometric models in this study include linear regression model, binary logit model, multinominal logit model and fractional split model. The binary logit model is a simple variant of multinomial logit model with only two alternatives. In this section, we will describe linear regression model, multinomial logit model and fractional split model.

6.2.1 Linear Regression Model

Linear regression models are employed to model continuous dependent variables such as population change, employment-population ratio, and median income. Let us assume that q (q = 1, 2, …, Q) be an index to a block group/census tract, t (t = 1, 2, 3, …, T) represents the different years. Let, y_{qt} represent the observed value of the dependent variable (population change/median income) at q, on year t. Thus, the equation for modeling can be written as:

$$y_{qt}^{*} = \alpha' x_{q,t-1} + \varepsilon_{qt} \tag{1}$$

where, y_{qt}^{*} is the predicted value for spatial unit q, for year t. $x_{q,t-1}$ is a matrix of attributes that influence the dependent variable (including a scalar constant); α is the vector of coefficients corresponding to the attributes for year *t-1*. Further, ε_{qt} is an idiosyncratic random error term assumed independently normally distributed with variance λ^2. The probability for y_{qt} in year t is given by:

$$P(y_{qt}) = \frac{\phi\left[\frac{y_{qt} - \alpha' x_{q,t-1}}{\lambda}\right]}{\lambda} \tag{2}$$

where ϕ(.) is the standard normal probability distribution function. Now, we can express the log-likelihood function as follows:

$$\text{LL} = \sum_{q=1}^{Q} \sum_{t=1}^{T} \ln[P(y_{qt})] \tag{3}$$

The model is estimated by maximizing the log-likelihood function presented in equation 3.

6.2.2 Multinomial Logit Model

In this project, we will employ multinomial logit model (binary logit for dichotomous variables) to model land use change, type of change (full/partial conversion), and new land use type. Let us assume that i (= 1, 2, …, I) be an index to a parcel, and t (t = 1, 2, 3, …, T) represents the different years. Let, v_{qt} represents the dependent variable (e.g., new land use type) with K categories (k=1, 2, …, K). In MNL formulation, the probability of a category, k can be written as follows:

$$\mathrm{P}(v_{it} = k) = \frac{e^{\beta_k X_{i,k,t-1}}}{\sum_{j=1}^{K} e^{\beta_k X_{i,j,t-1}}} \tag{4}$$

Now, we can express the log-likelihood function as follows:

$$\mathrm{LL} = \sum_{i=1}^{I} \sum_{t=1}^{T} \sum_{k=1}^{K} \ln[\mathrm{P}(v_{it} = k)^{m_{itk}}] \tag{5}$$

Where, m_{itk} is 1 if chosen alternative for parcel i at year t is k, 0 otherwise. The model is estimated by maximizing the log-likelihood function presented in equation 5.

6.2.3 MNL Fractional Split Model

In this research, we will employ fraction split model to identify vehicle ownership share and share of unchanged and new land uses. In this section, we discuss the model formulation in terms of a selected dependent variable: parcel level share of unchanged and new land use. Let S_{itr} be the fraction of land area specific to alternative $r\ (= 1, 2, \ldots, R)$ in year t where $R = 2$. Thus, the functional form of the econometric specification for fractional split component can be expressed as:

$$0 \le S_{itr} \le 1, \qquad \sum_{r=1}^{R} S_{itr} = 1 \quad \forall\, i, t \tag{6}$$

$$E[S_{itr} | d_{itr}] = G_{itr}(.) \tag{7}$$

$$0 < G_{itr}(.) < 1 \qquad\qquad \sum_{r=1}^{R} G_{itr}(.) = 1 \ \ \forall\, i, t \tag{8}$$

where, the land area fraction S_{itr} be a function of a vector d_{itr} of relevant explanatory variables associated with parcel i for time period t. $G_{itr}(.)$ $(i = 1, 2, \ldots, I)$ is a predetermined function. The properties specified in Equation 8 for $G_{itr}(.)$ warrant that the predicted fractional land area will range between 0 and 1; and will add up to 1 across all land use types.

In the current study context, we assume a categorical discrete outcome structure for G_{itr} in the fractional split model of equation 8. Thus, equation 8 can be rewritten as:

$$E[S_{itr} | d_{itr}] = \{\beta_r d_{itr} + \xi_{itr}\} \tag{9}$$

where, d_{itr} is a vector of attributes, β is the corresponding vector of coefficients to be estimated. ξ_{itr} is the random component assumed to follow a Gumbel type-I distribution. The probability for fractional split component takes the form:

$$R_{itr} = G_{itr}(S_{itr}) = \frac{exp\{\beta_r d_{itr}\}}{\sum_{j=1}^{R} exp\{\beta_r d_{itr}\}} \ \ \forall\, i, t \tag{10}$$

Finally, the log-likelihood function is:

$$LL = \sum_{i=1}^{I} \sum_{t=1}^{T} \sum_{r=1}^{R} \ln[(R_{itr})^{S_{itr}}] \tag{11}$$

All the parameters in the model are estimated by maximizing the LL presented in equation 11.

7 ESTIMATION RESULTS

In this section, we present and discuss estimated models for sociodemographic, land use (for a chosen land use type) and economic development variables.

7.1 Socio-demographic Models

7.1.1 Population Model

For forecasting future population, we develop a linear regression model of population change at the block group resolution. The estimated model is presented in Table 15. From the table, it is observed that population change is driven by various factors including previous year population, race distribution, job density and change in single-family residential percentage at the block group level. It is important to note that we calibrate population model prediction using county level predictions provided by Bureau of Economic and Business Research. To elaborate, we aggregate our block group level prediction at the county level and identify county specific calibration factors. Then we apply the calibration factors to the corresponding block group level predictions. This process ensures the predicted populations are not over or underestimated.

Table 15 Linear Regression Model of Population Change

Variable	Estimate	t statistic
Constant	29.123	6.065
Previous year population at the block group	-0.004	-2.639
Hispanic (%) at the block group	-0.181	-1.817
Job density at the county	-13.071	-2.805
Change in single-family residential share (%) at the block group	-1.079	-2.432

7.1.2 Household Vehicle Ownership Share

For forecasting future household vehicle ownership share, we develop a multinomial logit based fractional split model at the census tract resolution. The estimated model is presented in Table 16. From the table, it is observed that vehicle ownership level is significantly correlated with previous year's vehicle ownership level and census tract level median income.

Table 16 Multinomial Logit based Fractional Split Model of Vehicle Ownership

Variable	1-Vehicle		0-Vehicle		2-Vehicles		3 or more Vehicles	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	--	--	0.643	24.086	-2.668	-201.729	-5.673	-294.794
Lagged average household vehicle	--	--	-1.164	-52.500	1.442	151.713	2.800	222.768
Median income	--	--	-0.014	-34.766	0.004	29.980	-0.002	-15.196

7.1.3 Race/Ethnicity Distribution

In this study, we develop a multinomial logit (MNL) based fractional split model of race/ethnicity distribution at the block group resolution. The estimated model is presented in the following table. From the table, it is found that race/ethnicity distribution is dependent on previous year's race/ethnicity distribution, household density, median income and job density.

Table 17 MNL based Fractional Split Model of Race/Ethnicity Distribution (Base: White)

Variable	Hispanic		Black American		Asian		Other Race	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-3.182	-282.285	-3.368	-153.959	-5.096	-163.385	-4.387	-199.318
% Hispanic	0.063	284.097	0.031	91.850	0.024	41.790	0.018	36.693
% Black American	0.031	97.718	0.072	243.751	0.023	34.842	0.030	66.815
% Asian	0.025	17.816	0.041	25.540	0.153	39.438	0.034	16.435
% Other Race	0.020	8.857	0.040	19.261	0.034	8.935	0.147	30.081
Household Density	0.003	2.009	-0.028	-9.702	0.009	3.348	--	--
Median Income	--	--	-0.005	-15.297	0.005	12.994	--	--
Job Density	0.129	13.700	--	--	0.252	10.788	--	--

7.1.4 Number of Households

From the dataset, we observed that census tract level population and number of households are highly correlated. Therefore, we estimate a conversion factor (2.68 members/household) from the observed data to convert population forecasts into number of households at the census tract resolution.

7.2 Land Use Models

In this subsection, we describe estimated land use models for single family residential parcels. For other land use types, please see the model components presented in the Appendix section (section 12.2).

7.2.1 Binary Logit Model of Land Use Change

Binary logit (BL) component identifies whether land use of a vacant parcel changes or not in a given year. The result of the analysis is presented in Table 18. From the table, we find that the land use change probability for single family residential parcels depends on race/ethnicity distribution, vehicle ownership level, job density, parcel area, block group (BG) level land use patterns, flood risk zone.

Table 18 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-4.333	-52.797
Block group level Race Distribution (Base: % Other Race groups)		
% Hispanic	-0.015	-8.528
Census tract level vehicle ownership (Base: % HHs with vehicles)		
% Zero Vehicle HHs	0.021	4.852
Job density	0.205	3.634
Ln(Parcel area in acre)	-0.435	-15.306
Block group level Land Use (% by area) (Base: Other Land Uses)		
Single-family Residential	-0.020	-14.962
Multi-family Residential	0.012	2.837
% Flood Zone A	0.007	2.817

7.2.2 Binary Logit Model of Full/Partial Change

This component in the framework identifies if there will be a full/partial land use change in a year. The result of the analysis is presented in the following table. From the results, we find that full/partial decision is dependent on several factors including race/ethnicity distribution, vehicle ownership level, job density, parcel area and block group level land use patterns.

Table 19 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	-0.647	-15.894
BG level Race Distribution (Base: % White, Black American and Other Race)		
% Hispanic	0.013	21.618
% Asian	-0.056	-15.692
CT level vehicle ownership (Base: % HHs with vehicles)		
% Zero Vehicle HHs	0.029	20.975
Job density (per acre)	-0.515	-21.073
Ln(parcel area in acre)	0.588	75.955
BG level Land Use (% by area) (Base: Other LUs)		
Single Family Residential	0.010	20.954
Mixed Use	0.162	17.130
Vacant Land Use	-0.004	-6.619
Land use mix	-1.096	-16.826

7.2.3 MNL based Fractional Split Model

Using the estimated fractional split model for partially developed single family residential parcels, we identify the proportion of the new land use type. The result of the analysis is presented in Table 20. From the table, it is evident that the proportion of new land use type is significantly influenced by population density, race/ethnicity distribution, job density, parcel area, and block group level land use patterns.

Table 20 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.498	-97.562
Population density	-0.019	-10.052
BG level Race Distribution (Base: % Other Race Groups)		
% Black American	-0.005	-16.280
% Asian	-0.009	-6.935
Job density	-0.393	-29.404
Ln(Parcel area in acre)	-0.017	-2.850
BG level Land Use (% by area) (Base: Other LUs)		
Single Family Residential	-0.004	-13.956
Mixed Use	0.062	9.861
Commercial	-0.012	-20.465
Vacant Land Use	-0.005	-14.264

7.2.4 Multinomial Logit Model of New Land Use Type

Using the estimated multinomial logit model, we identify the new land use type of single-family residential parcels given a change is expected. The result of the analysis is presented in Table 21. From the table, it is evident that the new land use type is significantly influenced by population, race/ethnicity distribution, vehicle ownership level, median income, job density, parcel area and land use pattern at the corresponding block group. In the estimated MNL model, we aggregate new land use types with considerable small share into "low share categories". "Low share categories" is created in a way that its share remains below 15%. In future forecasting, we again expand it to individual land use types using their observed share in the data. For example, Low share category includes land use types: A, B, and C. In the observed data, single family residential parcels convert to these categories by 3.5%, 4% and 2.5%, respectfully adding up to 10%. Now, we forecast 20% share for "low share categories" for a given year. In such scenario, we perform probabilistic assignment of new land use in way that shares for A, B, and C categories become 7%, 8%, and 5%, respectfully.

7.3 Economic Development Variables

Economic development variables considered include number of jobs, number of jobs by industry, number of businesses and median income. Among the variables, number of jobs and median income are modelled using linear regression model while number of jobs by industry is modelled using MNL fractional split model. As we observed very strong correlation between number of jobs and number of businesses, we employ a conversion factor for estimating number of businesses. Independent variables for these models are processed from parcel level land use data, sociodemographic and economic development variables from the previous year.

7.3.1 Number of Jobs

Number of jobs is modelled using a linear regression model at the county resolution. The estimated model is presented in Table 22. From the estimated model, it is observed that number of jobs at the county is dependent on county population and percentage of agricultural, institutional and office land use in the previous year. To elaborate, an increase of population increases number of jobs in the county. Similarly, if percentage of agricultural, institutional and office land use is higher, number of jobs is also likely to be higher.

Table 21 MNL Model of New Land Use Type (Base: Other Residential)

Variable	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	0.784	18.591	-1.106	-17.035	-1.380	-22.028	-2.208	-25.979	-1.065	-9.971	0.793	12.623	-1.522	-26.308
Pop density (per acre)	-0.061	-18.932	-0.091	-18.970	--	--	--	--	--	--	-0.379	-20.561	-0.075	-20.038
BG level Race Distribution (Base: % Other Race Groups)														
% Black American	0.009	21.119	--	--	--	--	--	--	0.004	4.323	--	--	0.008	15.461
% Asian	-0.085	-30.646	--	--	-0.066	-15.692	--	--	--	--	-0.054	-7.886	-0.030	-11.219
CT level vehicle ownership (Base: % HHs with vehicles)														
% Zero Vehicle HHs	0.085	48.267	--	--	0.103	46.386	--	--	0.053	14.478	--	--	0.085	43.428
Median income (k)	--	--	0.005	9.388	-0.017	-18.545	--	--	-0.017	-14.696	--	--	--	--
Job density (per acre)	-0.604	-30.580	-0.826	-32.742	--	--	-1.656	-43.601	-1.308	-31.266	--	--	--	--
Ln(Parcel area in acre)	0.340	47.126	--	--	0.369	34.877	--	--	0.334	24.743	0.978	68.899	0.224	26.232
BG level Land Use (% by area) (Base: Other LUs)														
Single Family Residential	0.023	44.469	0.015	20.879	0.034	53.527	0.012	11.931	0.028	31.147	--	--	0.023	36.839
Vacant land use	0.026	50.927	--	--	--	--	-0.046	-21.718	-0.024	-12.748	--	--	--	--
Land use mix	-1.934	-31.173	0.485	5.824	--	--	2.671	20.756	1.122	8.856	-2.063	-16.307	0.474	5.777

Table 22 Linear Regression Model of Number of Jobs

Variable	Estimate	t Statistic
Constant	-55.405	-9.129
Lagged Population in thousand	0.674	127.053
% of land use types in the previous year		
Agricultural	0.472	5.209
Institutional	0.927	2.738
Office	27.907	3.898

7.3.2 Number of Jobs by Industry

Number of jobs by industry is identified by predicted total number of jobs and its share by industry. Job share by industry is modelled using MNL based fractional split model and the estimated model is presented in Table 23. From the table, it is found that share of jobs by industry is mainly dependent on land use pattern at the county level such as percentage of agricultural, industrial, institutional and commercial land use.

Table 23 MNL Based Fractional Split Model of Job Share by Industry (Base: Other Industries)

Variable	Accommodation		Administrative		Government		Health Care		Other Services		Professional		Real Estate		Retail	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	-0.748	-11.150	-1.544	-20.611	-0.571	-6.938	-0.961	-11.074	-1.330	-33.042	-1.481	-23.899	-1.299	-19.473	-0.765	-16.810
% Agricultural	-0.012	-10.814	-0.004	-3.799	0.003	3.074	-0.008	-5.093	-0.004	-4.943	-0.012	-11.540	-0.011	-10.208	-0.004	-5.352
% Industrial	-0.168	-7.110	--	--	0.045	13.648	-0.105	-3.014	--	--	0.013	2.754	-0.167	-4.207	--	--
% Institutional	0.022	6.938	0.018	6.554	0.018	6.782	0.011	4.066	0.008	6.656	0.025	14.106	0.019	5.212	0.011	7.079
% Commercial	--	--	0.063	3.992	-0.256	-9.336	0.089	4.460	-0.027	-3.291	0.051	3.882	0.056	3.078	-0.029	-3.417

7.3.3 Median Income

Median income is modelled at the census tract level using a linear regression model. The estimated model is presented in Table 23. Independent variables influencing median income include previous year's median income, population density, job density, percentage of industrial and office land uses and land use diversity at the block group resolution.

Table 24 Linear Regression Model of Median Income (Thousand)

Variable	Estimate	t statistic
Constant	0.985	4.991
Previous median income (in thousand)	1.002	550.060
Lagged population density	-0.021	-3.086
Job density in the previous year	0.694	8.006
% Industrial in the previous year	-0.019	-2.602
% Office in the previous year	0.057	4.372
Land use mix	-0.783	-2.830

7.3.4 Number of Businesses

Number of business establishments is highly correlated with number of jobs in the corresponding county. From the observed data, we computed a conversion factor (12.88 jobs/business) between number of jobs and number of businesses. We employ this conversion factor and predicted number of jobs to forecast future number of businesses at the county resolution.

8 FORECASTING PROCEDURE

For forecasting the selected variables into the future, we formulate a framework that uses the developed models and a proposed microsimulation approach. The employed framework is presented in following Figure 14. The framework includes mainly four components: 1) land use, sociodemographic and economic development models, 2) microsimulation component, 3) data storage, and 4) data aggregator. For a given year, the framework identifies the probabilities of different alternatives of land use models. Similarly, demographic and economic development models predict future values of the variables considered. For example, binary logit model of change/no change identifies the probabilities of the two alternatives at the parcel resolution (change and no change). Population model determines the block group level population at a given year.

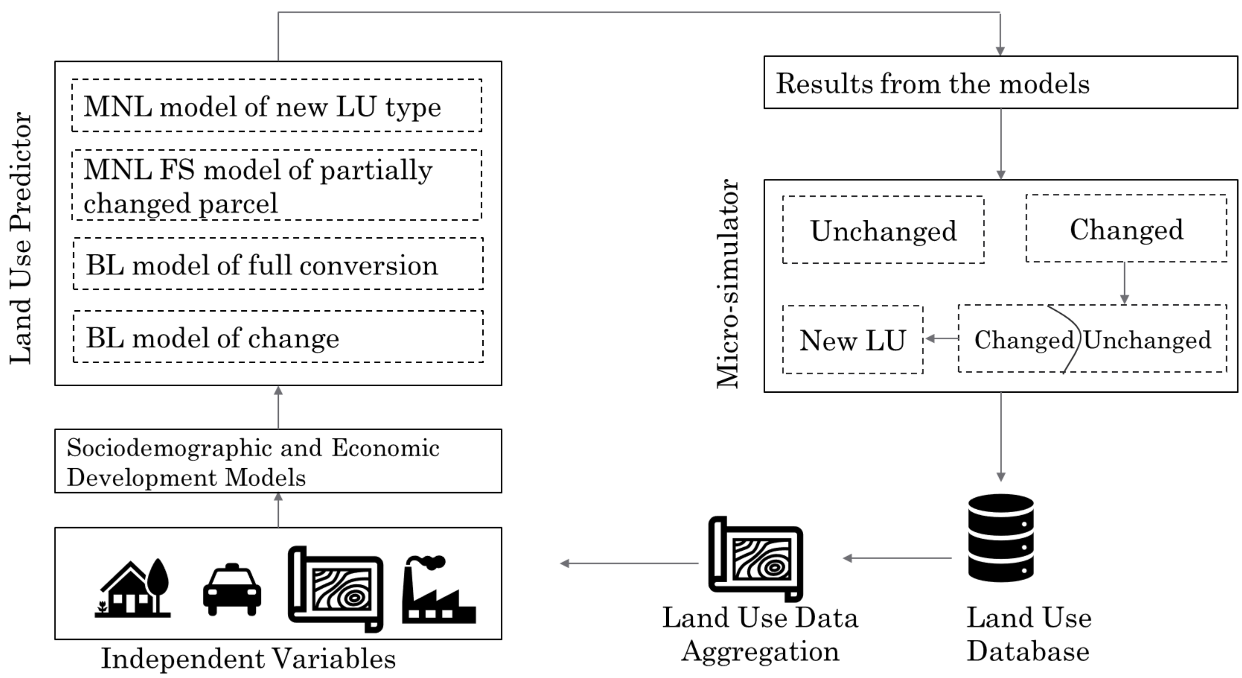


Figure 14 Forecasting Framework

Next, a microsimulation component simulates parcel level land use for a given year based on probabilities identified by the developed land use model components. The steps performed by the simulator are illustrated in Figure 15. Basically, it translates the probabilities into a predicted alternative. For example, we identify probability of land use change from a binary logit model and draw a random number from a uniform distribution between 0 and 1. If the probability of change is higher than the random number, our forecast will suggest a change. Thus, we follow a probabilistic assignment process to translate probabilities into a decision. Next, we save the data into a data storage at the desired resolution. Finally, we aggregate the variables at different resolutions for getting the next year independent variables ready. For example, we employ county population as an independent variable in county level number of jobs model. Therefore, we aggregate block group population to county population using the data aggregator. We complete this procedure for each year starting from 2021 through 2050.

8.1 Natural Conservation Area

In a micro simulation process, there is a small probability for unexpected changes. For example, it is theoretically possible that conservation areas can be altered into different land use types. However, as these changes are unlikely to happen without significant public involvement, we imposed constraints on altering parcels in proximity to high proportion of conservation area. Conservation areas are identified at the block group resolution using GIS data sourced from Florida Natural Areas Inventory. From the GIS data, we select block groups with at least 70% area identified as conservation area. For parcels within these selected block groups, we do not allow any land use changes. The selected block groups, as expected, amount to a small share of the total block groups in Florida (1.12%).

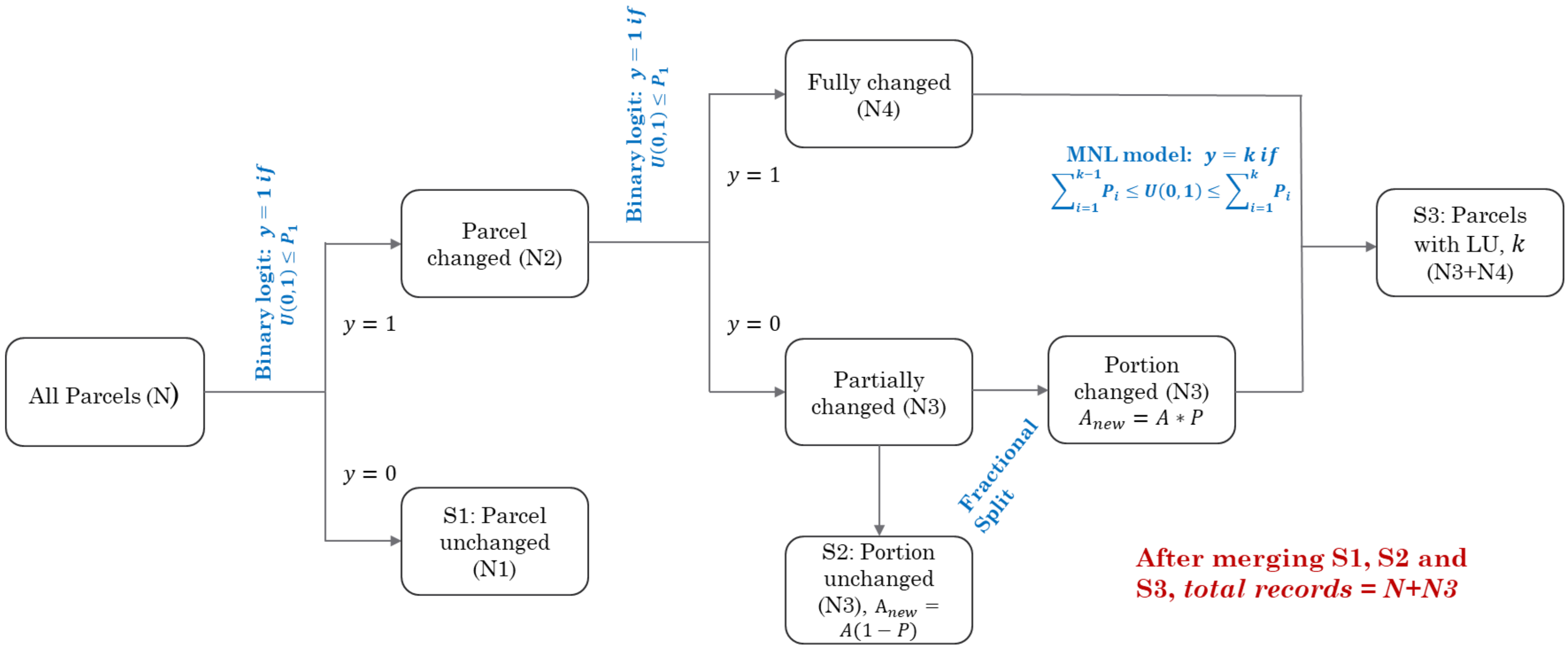


Figure 15 Parcel Land Use Simulation Process

9 FORECASTING RESULTS

In this study, we forecast sociodemographic, land use and economic development variables from 2020 through 2050 in a 5-year interval (2025, 2030, 2035, 2040, 2045 and 2050). Sociodemographic and economic development variables are forecasted at the finest resolution based on data availability. Land use is projected at the parcel level and aggregated at different resolutions including block group, census tract and county. The forecasted data are delivered in two formats: a set of datafiles (.csv format) and a set of GIS shapefiles (.shp format). In the following sections, we provide an illustration of the forecasted data by variable group. We also present aggregated results at the state level to check the consistency of the future predictions.

9.1 Sociodemographic and Economic Development Variables

Among sociodemographic variables, we project population (block group), household vehicle ownership share (census tract), race/ethnicity distribution (block group) and number of households (census tract). Among economic development variables, we project number of jobs (county), number of businesses (county), number of jobs by industry (county) and median income (census tract). A sample of block group level and census tract level sociodemographic and economic development data are shown in the following Figure 15. In addition, we present population, and zero vehicle household share as GIS layers in Figure 17.

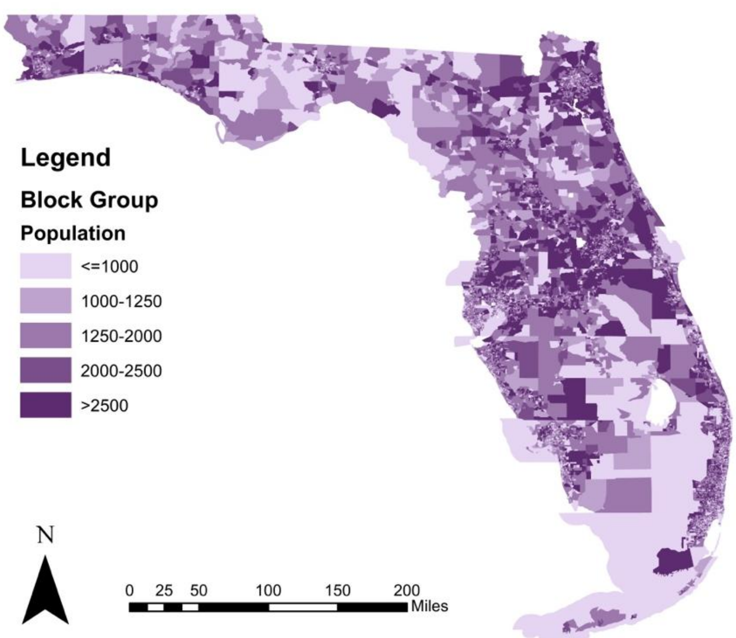
	A	B	C	D	E	F	G	H
1	BG.ID	BG.Popula	BG.Pop_d	BG.Hispar	BG.White	BG.Black_	BG.Asian	BG.Other_
2	120010002011	863.22	8.80	16.05	69.71	8.87	2.10	3.27
3	120010002012	1239.64	13.50	10.40	80.24	5.29	1.66	2.41
4	120010002013	1086.21	11.48	7.90	84.51	4.14	1.42	2.03
5	120010002014	1215.63	56.50	8.74	83.04	4.54	1.51	2.17
6	120010002021	1079.55	10.19	10.97	78.52	6.59	1.36	2.56
7	120010002022	1149.88	18.13	8.28	83.59	4.90	1.16	2.07
8	120010002023	2281.55	53.66	7.68	84.72	4.54	1.11	1.96
9	120010003011	2171.00	7.08	11.25	77.25	7.25	1.57	2.69
10	120010003012	2592.54	8.32	10.28	79.19	6.53	1.49	2.51
11	120010003021	581.17	1.36	11.87	74.77	8.84	1.61	2.91
12	120010003022	993.31	5.04	13.56	19.29	63.05	1.17	2.94
13	120010003023	1060.20	3.29	9.73	79.61	6.75	1.44	2.48
14	120010004001	1259.45	2.57	3.96	4.26	90.47	0.35	0.96
15	120010004002	791.25	3.74	10.05	12.53	74.31	0.88	2.23
16	120010004003	1621.98	6.39	9.75	80.04	6.30	1.48	2.43
17	120010004004	2981.65	5.58	5.09	5.59	87.66	0.45	1.21
18	120010005001	1522.65	4.45	8.86	82.06	5.29	1.51	2.28
19	120010005002	753.06	4.22	14.15	71.14	9.52	1.95	3.24
20	120010005003	926.37	5.04	7.55	84.61	4.48	1.35	2.01

(a) Block Group Level Sociodemographic and Economic Development Variable Forecast for 2025

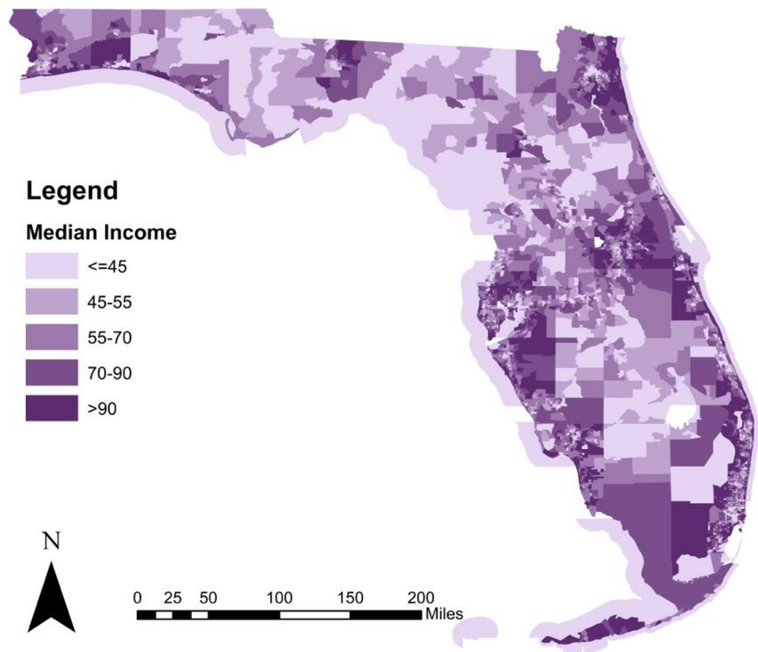
	A	B	C	D	E	F	G	H	I
1	CT.ID	CT.HH	CT.HH_de	CT.No_vel	CT.Veh1	CT.Veh2	CT.Veh3pl	CT.Income	CT.INC2
2	12001000201	1643.54	5.37	7.62	47.52	35.05	9.81	52127.49	52.13
3	12001000202	1683.20	7.94	23.92	53.42	18.82	3.84	12472.03	12.47
4	12001000301	1777.44	2.88	12.95	52.95	27.71	6.39	38908.46	38.91
5	12001000302	983.09	1.04	10.11	49.23	31.78	8.88	39548.60	39.55
6	12001000400	2482.96	1.67	10.66	51.29	30.52	7.53	44441.99	44.44
7	12001000500	2045.14	2.11	8.56	49.79	33.25	8.40	53343.22	53.34
8	12001000600	2238.24	1.18	18.67	54.58	22.22	4.54	26934.70	26.93
9	12001000700	2875.51	0.51	6.13	40.81	38.15	14.91	40948.73	40.95
10	12001000806	1190.81	5.07	19.79	54.53	21.37	4.31	24050.37	24.05
11	12001000808	1393.31	2.00	8.02	45.04	35.11	11.83	38565.84	38.57
12	12001001000	2851.70	2.04	4.47	35.43	40.78	19.31	41476.07	41.48
13	12001001100	2724.21	1.41	2.29	35.46	46.83	15.43	93067.41	93.07
14	12001001202	3386.41	2.33	2.73	34.32	45.16	17.79	73842.37	73.84
15	12001001400	2014.51	0.37	2.82	30.11	43.72	23.35	51738.17	51.74
16	12001001514	768.84	1.91	14.17	52.30	26.93	6.60	30847.40	30.85
17	12001001515	2200.13	5.72	19.18	53.97	22.12	4.72	22774.04	22.77
18	12001001516	1003.86	7.74	17.01	53.05	24.27	5.67	23954.80	23.95
19	12001001517	2205.32	5.91	12.55	50.52	29.02	7.91	30462.58	30.46
20	12001001522	2783.95	2.52	16.39	53.53	24.54	5.53	28153.01	28.15

(b) Census Tract Level Sociodemographic and Economic Development Variable Forecast for 2025

Figure 16 Sociodemographic and Economic Development Variable Forecasts



(a) Block Group Level Population for 2025



(b) Census Tract Level Median Income (thousand) for 2025

Figure 17 Sociodemographic and Economic Development Variable GIS Layers for 2025

9.2 Land Use Variables

Land use variables are forecasted using the microsimulation procedure presented in Figure 3. Parcel level forecasts are aggregated at various resolutions. Along with this deliverable, we provide our forecasted data using four data files including parcel, block group, census tract and county files in .csv format. We also provide GIS layers using county shapefiles similar to FDOR shapefiles. In the GIS layers, we join forecasted parcel land use with geometric attributes so that they can be useful for any future analysis. Parcel, block group, census tract and county datafiles are illustrated in Figure 18. We also show county level land use forecast map for 2025 in Figure 19.

	A	B	C	D	E	F	G	H
1	Par_uniq	PARCELNC	x	y	Landuse	BG.ID	Parcel_Area	Rank
2	1.12E+11	07702-000	-82.2898	29.80339	Agricultur	1.2E+11	1512003.2	1
3	1.12E+11	03206-000	-82.4824	29.79493	Others	1.2E+11	1070755.7	1
4	1.12E+11	03956-010	-82.4731	29.78104	Industrial	1.2E+11	255474.0	1
5	1.12E+11	03956-010	-82.4738	29.77931	Industrial	1.2E+11	358128.7	1
6	1.12E+11	05608-001	-82.4535	29.84439	VResident	1.2E+11	31477.4	1
7	1.12E+11	16979-000	-82.1648	29.80905	Others	1.2E+11	87119.0	1
8	1.12E+11	03956-010	-82.474	29.78083	VCommer	1.2E+11	44032.1	1
9	1.12E+11	17125-000	-82.1805	29.79086	VResident	1.2E+11	43904.3	1
10	1.12E+11	17125-001	-82.1811	29.79048	SingleFam	1.2E+11	165158.3	1
11	1.12E+11	05900-226	-82.417	29.75963	OtherResi	1.2E+11	13348.1	1
12	1.12E+11	05900-221	-82.4177	29.75855	OtherResi	1.2E+11	24975.1	1
13	1.12E+11	16972-029	-82.1738	29.81743	MultiFami	1.2E+11	143551.4	1
14	1.12E+11	05899-001	-82.4144	29.7671	VCommer	1.2E+11	108754.8	1
15	1.12E+11	17549-005	-82.2378	29.75059	SingleFam	1.2E+11	365818.9	1
16	1.12E+11	16979-001	-82.1655	29.80623	Agricultur	1.2E+11	386318.9	1
17	1.12E+11	05506-000	-82.4006	29.84741	Agricultur	1.2E+11	220222.0	1
18	1.12E+11	01636-006	-82.5889	29.77286	Agricultur	1.2E+11	412940.4	1
19	1.12E+11	01636-000	-82.5874	29.77201	Agricultur	1.2E+11	377262.2	1
20	1.12E+11	05949-005	-82.4377	29.76882	Agricultur	1.2E+11	4750499.2	1

(a) Parcel Level Land Use Forecast for 2025

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	BG.ID	BG.Agri	BG.AllV	BG.Con	BG.Indu	BG.Inst	BG.Mix	BG.Mul	BG.Offi	BG.Oth	BG.Oth	BG.Pub	BG.Rec	BG.Sing	BG.Wat	BG.Land
2	120010002011	0.00	18.97	5.79	0.01	7.84	1.11	7.42	1.52	2.25	2.93	7.35	0.49	44.32	0.00	0.71
3	120010002012	0.00	12.51	6.54	0.69	0.85	0.52	14.44	11.35	2.15	0.43	12.62	0.35	37.55	0.00	0.73
4	120010002013	0.00	7.08	32.45	0.46	0.71	3.94	18.59	14.44	3.27	3.04	4.90	0.05	11.08	0.00	0.78
5	120010002014	0.00	7.40	11.13	0.00	19.26	3.70	49.37	2.60	3.01	2.54	0.00	0.00	0.99	0.00	0.71
6	120010002021	0.00	18.88	5.36	0.72	6.99	1.89	12.41	8.31	8.03	7.31	7.47	0.17	22.38	0.08	0.85
7	120010002022	0.00	10.30	0.22	0.00	32.99	0.00	39.13	3.48	6.07	0.33	0.53	0.17	6.79	0.00	0.65
8	120010002023	0.12	13.42	0.00	0.00	25.98	0.00	23.00	0.00	17.95	0.00	0.85	0.00	18.67	0.00	0.84
9	120010003011	0.00	9.22	14.72	3.11	1.57	0.43	21.66	7.86	4.85	0.17	10.11	0.57	25.71	0.01	0.78
10	120010003012	0.02	8.42	18.34	4.01	3.58	1.68	8.17	12.15	3.26	1.78	1.53	0.37	36.66	0.05	0.73
11	120010003021	0.00	11.13	22.14	30.34	3.14	0.12	1.77	1.05	1.37	0.73	13.08	0.11	15.02	0.00	0.74
12	120010003022	0.00	11.51	17.06	7.39	1.64	2.56	13.21	5.62	5.39	0.11	0.51	0.41	34.58	0.00	0.77
13	120010003023	0.03	11.11	21.39	0.00	5.52	0.00	6.59	6.42	2.98	0.11	0.48	0.34	45.02	0.00	0.67
14	120010004001	0.00	50.96	4.85	20.48	2.78	0.00	3.64	1.07	2.47	0.80	1.83	0.00	11.12	0.00	0.66
15	120010004002	0.15	5.18	1.37	2.58	2.97	0.83	2.00	0.19	0.63	0.59	20.61	0.07	62.82	0.02	0.47
16	120010004003	1.87	2.84	13.62	0.30	11.75	0.02	2.46	8.08	1.39	0.12	15.20	0.33	42.02	0.00	0.68
17	120010004004	15.48	7.91	22.93	0.22	4.16	0.00	3.73	0.32	1.03	2.10	8.44	0.15	33.53	0.00	0.74
18	120010005001	0.14	11.04	14.03	5.77	5.26	1.46	11.90	11.72	5.32	1.27	18.63	0.57	12.88	0.00	0.87
19	120010005002	0.00	0.68	10.38	1.54	4.33	0.20	3.46	2.07	0.23	0.24	27.33	0.50	49.05	0.00	0.58
20	120010005003	0.00	5.04	0.60	0.00	2.87	0.00	1.83	0.00	0.86	1.11	16.34	0.00	71.18	0.16	0.45

(b) Block Group Level Land Use Forecast for 2025

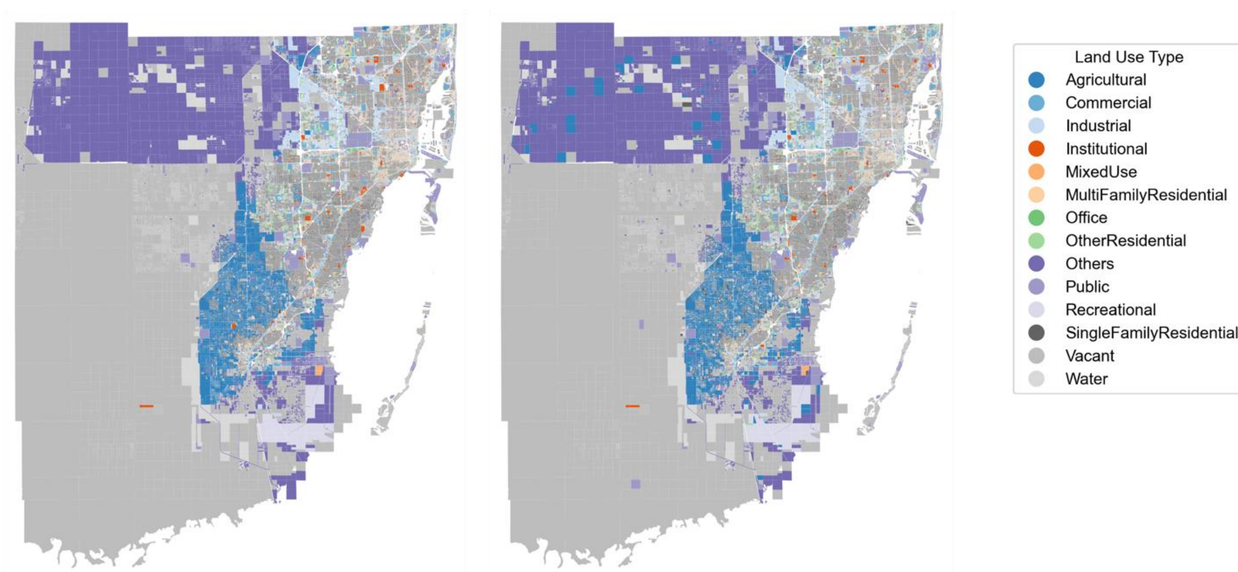
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	CT.ID	CT.Agri	CT.AllV	CT.Com	CT.Indu	CT.Insti	CT.Mixe	CT.Mult	CT.Offic	CT.Othe	CT.Othe	CT.Pub	CT.Recr	CT.Sing	CT.Wat	CT.Land
2	12001000201	0.00	12.54	14.63	0.35	4.34	1.99	15.93	8.54	2.59	2.19	7.66	0.28	28.96	0.00	0.82
3	12001000202	0.02	15.22	2.75	0.36	18.58	0.94	22.53	5.20	9.43	3.75	4.07	0.14	16.97	0.04	0.77
4	12001000301	0.01	8.82	16.54	3.56	2.58	1.06	14.86	10.02	4.05	0.98	5.79	0.47	31.23	0.03	0.76
5	12001000302	0.01	11.20	20.83	15.24	3.64	0.58	5.79	3.83	2.75	0.39	6.18	0.25	29.30	0.00	0.77
6	12001000400	5.89	20.81	12.34	7.23	4.83	0.12	3.24	1.87	1.51	1.12	9.15	0.12	31.77	0.00	0.75
7	12001000500	0.05	7.84	7.83	2.76	3.65	0.72	9.31	5.47	2.32	0.71	16.46	0.45	42.40	0.03	0.70
8	12001000600	7.10	13.93	4.55	1.42	4.23	0.25	2.01	0.12	1.11	7.35	42.39	0.22	15.28	0.04	0.69
9	12001000700	7.88	39.68	0.76	1.66	3.08	0.12	1.27	0.17	2.75	7.76	15.39	0.55	18.92	0.01	0.68
10	12001000806	0.21	5.11	7.38	19.77	22.76	0.00	24.82	3.04	6.76	3.63	0.68	0.02	5.83	0.00	0.79
11	12001000808	0.00	19.14	4.90	0.06	0.78	0.00	14.91	0.81	7.66	0.37	12.51	0.84	38.02	0.00	0.71
12	12001001000	0.01	17.83	1.71	0.00	2.66	0.13	3.84	1.18	1.10	0.52	6.29	0.05	64.69	0.00	0.48
13	12001001100	0.05	4.35	6.09	0.01	2.03	0.00	0.77	2.16	7.44	0.79	4.10	0.03	72.15	0.04	0.42
14	12001001202	0.06	8.94	1.76	0.52	5.66	0.00	6.81	0.87	11.21	3.24	3.70	3.44	53.78	0.02	0.62
15	12001001400	9.51	24.82	0.23	0.00	1.30	0.07	0.10	0.05	9.04	7.85	33.34	1.19	12.05	0.46	0.69
16	12001001514	0.00	3.92	8.44	1.88	27.62	0.00	22.14	2.35	8.55	0.04	23.41	0.08	1.55	0.00	0.76
17	12001001515	0.00	14.25	6.49	0.00	0.59	0.01	49.04	0.52	25.84	0.04	0.52	0.01	2.69	0.00	0.56
18	12001001516	0.00	5.75	0.00	0.00	3.74	0.00	44.66	0.00	42.72	0.92	0.06	0.00	2.16	0.00	0.59
19	12001001517	4.98	7.73	3.27	0.05	1.77	0.00	51.35	9.51	11.64	0.72	1.41	1.51	6.05	0.00	0.68
20	12001001522	3.64	18.08	27.67	2.34	5.59	1.73	17.71	0.95	10.85	2.71	6.64	0.11	1.98	0.00	0.78

(c) Census Tract Level Land Use Forecast for 2025

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	CNTY.ID	CNTY.A	CNTY.A	CNTY.C	CNTY.Ir	CNTY.Ir	CNTY.M	CNTY.M	CNTY.O	CNTY.O	CNTY.O	CNTY.P	CNTY.R	CNTY.S	CNTY.W	CNTY.La
2	1	52.42	17.88	1.13	0.53	1.19	0.07	0.53	0.22	5.15	3.41	3.90	0.58	10.86	2.12	0.60
3	3	43.27	1.76	0.31	0.08	0.12	0.01	0.13	0.15	1.84	4.98	3.76	40.81	2.78	0.01	0.49
4	5	33.26	9.08	0.78	0.39	5.03	0.08	0.34	0.23	2.17	2.19	2.85	0.07	4.72	0.03	0.47
5	7	65.41	8.60	0.44	0.25	0.44	0.03	0.29	0.06	3.27	5.31	10.33	0.03	5.55	0.00	0.47
6	9	14.13	43.80	1.64	0.79	0.61	0.26	0.72	0.41	3.03	3.31	3.65	0.10	11.73	0.13	0.55
7	11	0.68	1.31	2.97	1.30	0.70	0.09	1.20	0.51	4.52	56.79	1.81	10.48	9.71	2.00	0.55
8	13	90.16	2.71	0.19	0.08	0.12	0.00	0.02	0.03	1.34	1.93	0.61	0.26	2.54	0.01	0.19
9	15	21.49	33.70	1.54	0.27	0.29	0.02	0.27	0.18	1.59	4.54	1.77	12.48	6.24	15.64	0.69
10	17	13.16	23.16	1.36	0.18	0.41	0.10	0.14	0.12	3.41	4.02	6.51	6.74	9.02	4.16	0.63
11	19	30.86	30.32	1.06	0.83	0.57	0.08	0.32	0.27	5.75	9.12	3.63	5.16	11.96	0.05	0.68
12	21	11.37	2.32	1.48	0.18	0.20	0.02	0.14	0.04	0.95	3.56	75.30	0.11	4.02	0.30	0.37
13	23	51.46	4.74	0.52	0.21	0.33	0.04	0.12	0.12	6.02	3.69	10.90	15.86	5.88	0.11	0.59
14	27	83.60	5.45	0.43	0.22	0.12	0.01	0.14	0.16	0.86	4.12	1.37	0.14	3.35	0.03	0.28
15	29	55.06	2.11	0.10	0.07	0.04	0.01	0.01	0.01	1.40	0.61	10.32	0.01	1.33	1.0722	0.31
16	31	16.85	21.31	3.19	3.18	4.01	0.08	2.04	1.02	5.02	5.69	6.04	2.92	21.76	0.11	0.77
17	33	29.89	3.94	2.10	0.88	2.17	0.11	1.30	0.39	2.10	6.90	3.10	3.08	11.12	0.13	0.57
18	35	57.78	6.30	1.17	0.26	0.21	0.05	0.17	0.13	2.45	4.80	9.76	0.16	5.49	0.90	0.48
19	37	4.81	2.45	0.30	0.03	0.05	0.00	0.01	0.01	0.31	0.34	75.99	0.33	1.29	0.00	0.22
20	39	68.32	3.63	0.36	0.38	0.73	0.01	0.17	0.06	2.99	7.87	8.70	0.14	6.53	0.11	0.45

(d) County Level Land Use Forecast for 2025

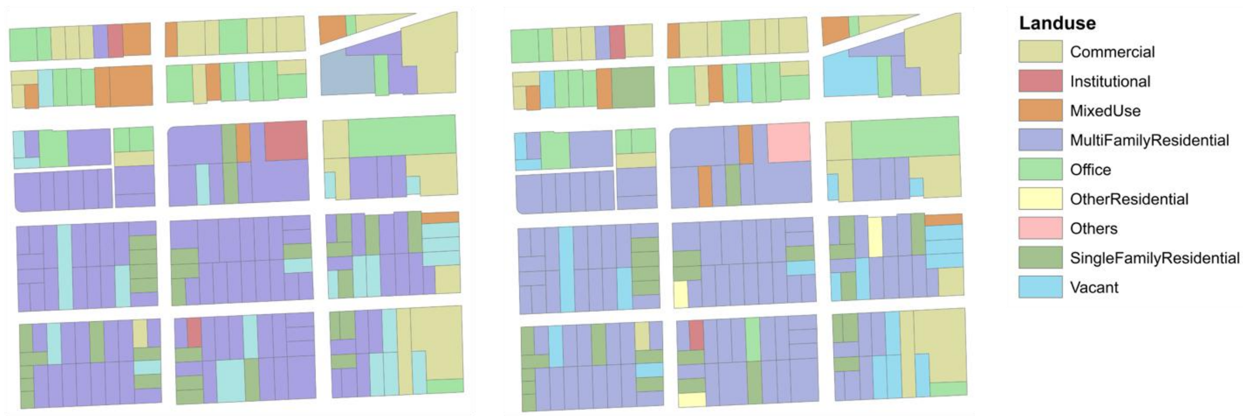
Figure 18 Land Use Forecasts at Different Resolution for 2025



Miami-Dade 2020 Miami-Dade 2025

(a) County Land Use Changes between 2020 and 2025[5]

[5] If a parcel splits into multiple parcels with different land uses in future, we consider the land use with the highest share (Rank=1) for preparation of the GIS layers.



Block Group- 0053031 (2020) Block Group- 0053031 (2025)

(b) Block Group Land Use Changes between 2020 and 2025

Figure 19 An Example of Future Land Use Changes

9.3 Prediction Consistency Analysis

To check for the accuracy of the forecasts, we perform a consistency analysis by comparing different variables over time. First, we compare percentages of single-family residential and multi-family residential land use area forecasts with population and number of households forecasts. Our forecasts are presented in Figure 20. From the figure, it is evident that single- and multi-family residential land increase over time and population and number of households increase proportionally in the future. In addition, we check the consistency of the forecasts by comparing population and number of households per acre area of single- and multi-family residential land uses. The results are presented in Figure 21. From the figure, we found that the measures remain almost constant over the years validating our forecasting approach.

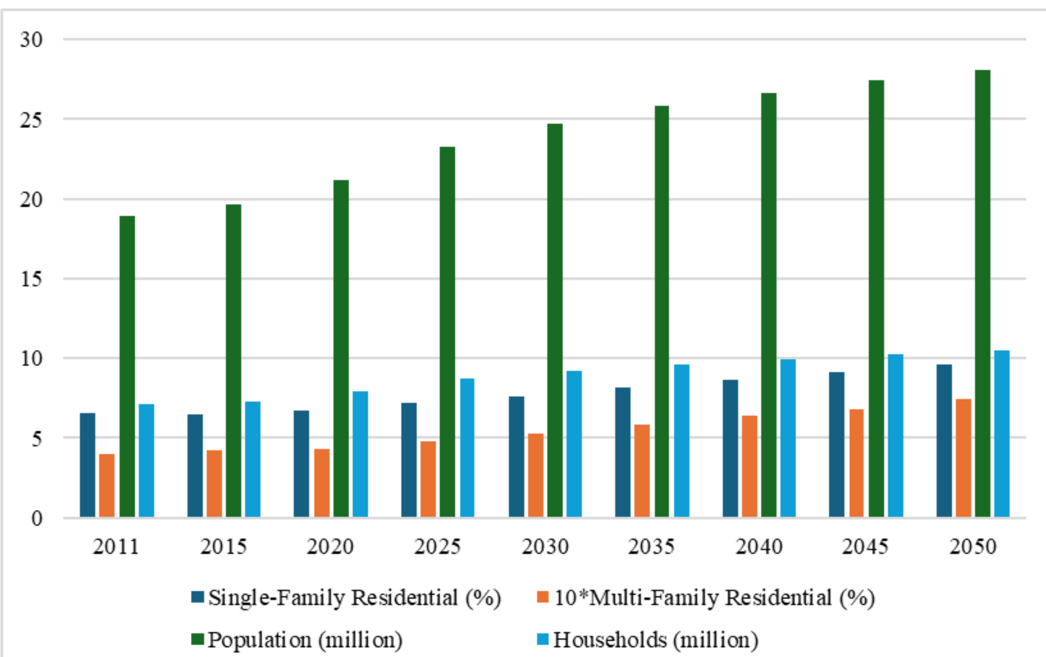
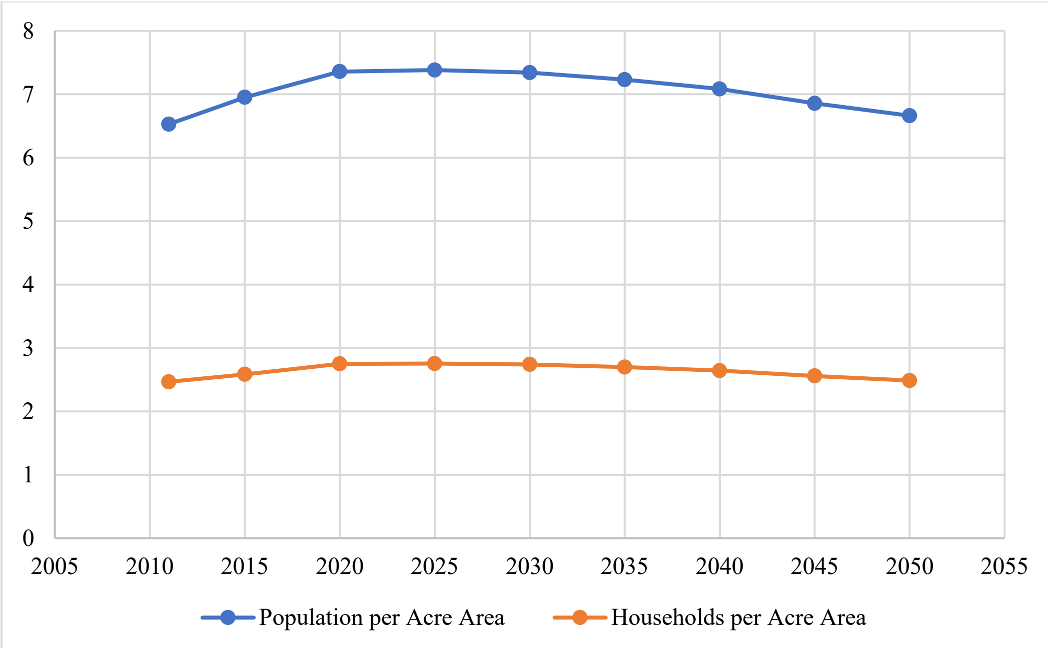
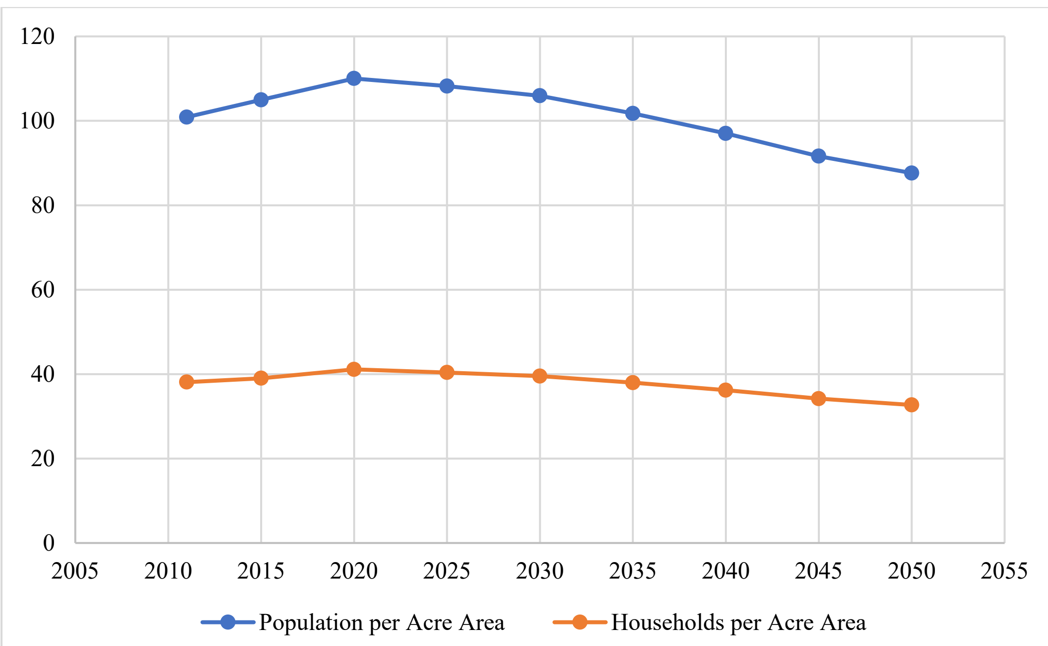


Figure 20 Residential Land Use, Population and Number of Households



(a) Single-family Residential Land Use



(b) Multi-family Residential Land Use

Figure 21 Population and Number of Households per Area

Next, we compare percentages of commercial, industrial and institutional land uses with number of jobs in Florida. This comparison can also validate the forecasting procedure we are following. The results are presented in Figure 22. From the figure, it is found that percentages of commercial and industrial land uses are expected to increase in the future while institutional land use is expected to decrease slightly. As expected, we also observe an increasing trend for number of jobs across the state.

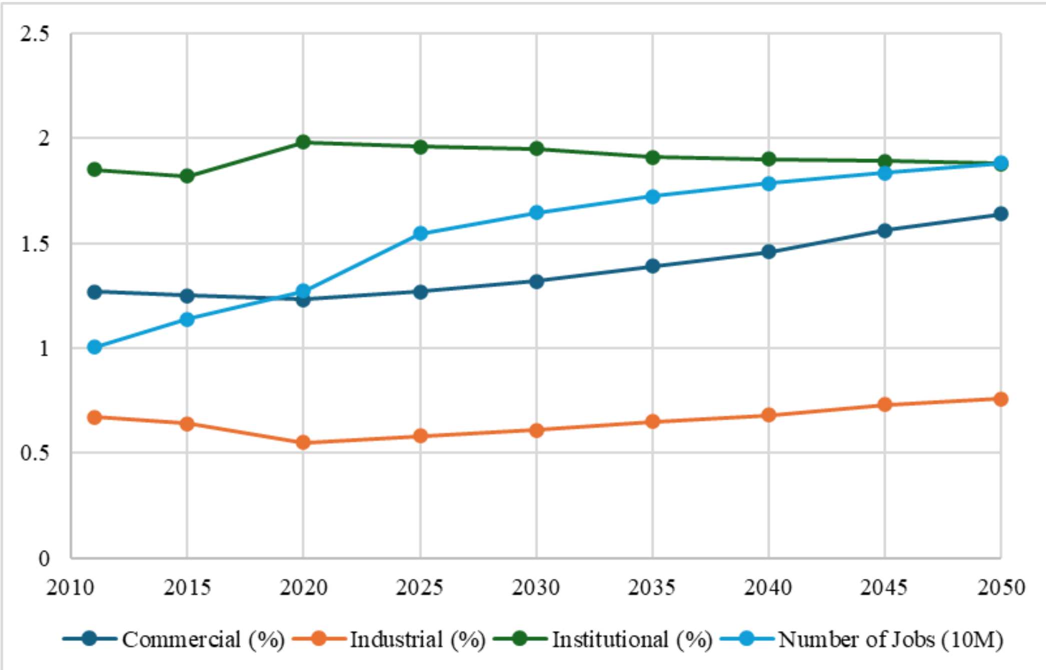


Figure 22 Commercial, Industrial and Institutional Land Uses and Number of Jobs

Next, we compare the number of jobs and household median income, and the results are presented in Figure 23. From the figure, we find that both the number of jobs and median income will increase in future which is intuitive.

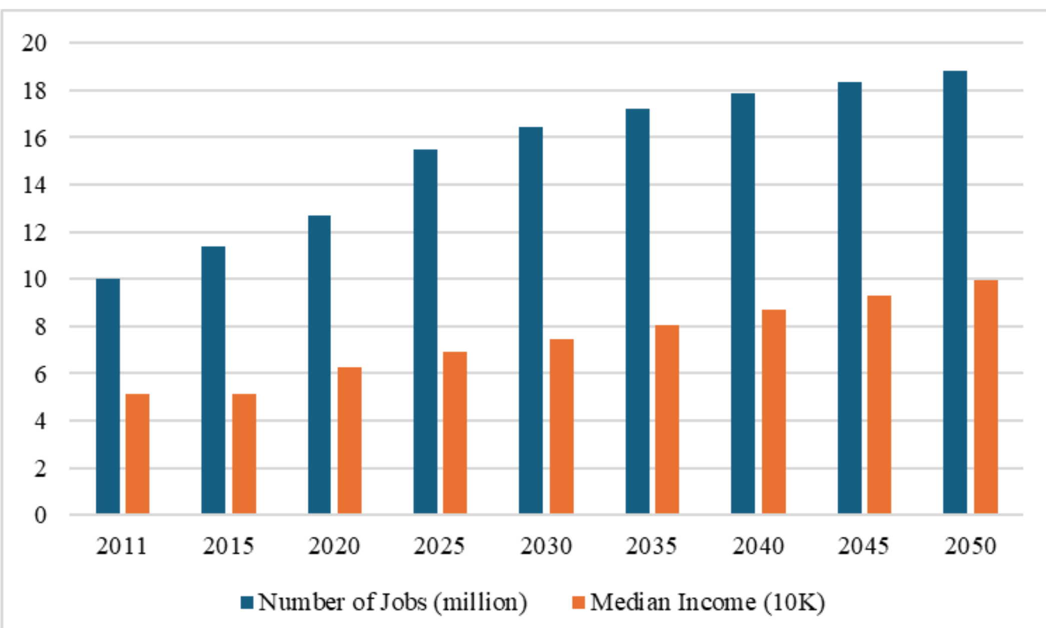


Figure 23 Number of Jobs and Median Income

Further, we compute job rate (job per capita) for the analysis year and for future time points. The results are summarized in the following table. From the analysis, it is evident that job per capita slightly increases in the future, which might be a result of land use development across the state.

Table 25 Job per Capita

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

Finally, 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. Therefore, we run our simulation three times with different seeds and compare different statistics including mean, standard deviation, 25th, 50th, and 75th percentiles. This analysis is performed for the last year of the forecasting horizon (2050). The results from block group, census tract and county level analysis are presented in Table 26-28. From the tables, it is evident that the selected statistics remain very consistent across the runs and different resolutions considered. The changes even when observed are very small and illustrate the stability of our forecasts.

Table 26 Block Group Level Consistency Check for 2050

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

Table 27 Census Tract Level Consistency Check for 2050

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

Table 28 County Level Consistency Check for 2050

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

10 DATAFILES DICTIONARY

Datafiles included with this deliverable consists of comma separated values (.csv) files and GIS shapefiles (.shp). For each year, we provide the datafiles in two folders. The first folder consists of four CSV files for four spatial resolutions: parcel, block group, census tract and county. Definitions of different fields are provided in Table 29. The first column of Table 29 includes field names in the dataset and the second column includes detailed definition of the fields. The second folder consists of parcel files for 67 counties in Florida. Attribute table of the shapefiles includes six columns: FDOR assigned parcel ID, generated unique parcel ID, x-coordinate, y-coordinate, area in square feet and land use type.

Table 29 Definition of Different Fields in Datafiles

Parcel File (Resolution: Parcel)	
Field Name	**Definition**
Par_uniq	Generated unique parcel ID
PARCELNO	Florida Department of Revenue (FDOR) assigned parcel ID
x	X-coordinate of parcel centroid
y	Y-coordinate of parcel centroid
Landuse	Forecasted land use type
Parcel_Area	Parcel area in square feet
Rank	Land area ranking by land use for each parcel
Block Group File (Resolution: Block Group)	
Field Name	**Definition**
BG.ID	Block group geoid
CT.ID	Corresponding census tract geoid
CNTY.ID	Corresponding county geoid
BG.Area	Area of block group in acre
BG.Population	Population
BG.Pop_density	Population density (per acre)
BG.Hispanic	Percentage of Hispanic population
BG.White	Percentage of White population
BG.Black_American	Percentage of Black/African American population
BG.Asian	Percentage of Asian population
BG.Other_Race	Percentage of Other races
BG.FLD_A	Percentage of flood zone A in a block group
BG.FLD_AE	Percentage of flood zone AE
BG.FLD_AH	Percentage of flood zone AH
BG.FLD_AO	Percentage of flood zone AO
BG.FLD_VE	Percentage of flood zone VE
BG.FLD_SFHA	Percentage of special flood hazard area including zone A, AE, AH, AO, VE. SFHA are areas having a 1 or more-percent chance of being inundated by the flood in any given year
BG.FLD_X	Percentage of areas with flood risk between 0.2-1.0%
BG.FLD_X1	Percentage of areas with flood risk
BG.FLD_WATER	Percentage of water
BG.FLD_OTHER	Percentage of areas not included above categories
BG.Agricultural	Percentage of agricultural land use (dor_uc: 50-69)
BG.AllVacant	Percentage of vacant land use (dor_uc: 0,10,40,70,80)
BG.Commercial	Percentage of commercial land use (dor_uc: 11-39)
BG.Industrial	Percentage of industrial land use (dor_uc: 41-49)
BG.Institutional	Percentage of institutional land use (dor_uc: 71-79,81,84)
BG.MixedUse	Percentage of mixed-use land use (dor_uc: 12)
BG.MultiFamilyResidential	Percentage of multi-family residential land use (dor_uc: 3,8)
BG.Office	Percentage of office land use (dor_uc: 17,18,19,23,24)
BG.OtherResidential	Percentage of other residential land use (dor_uc: 2,4,7,9)
BG.Others	Percentage of other land use (dor_uc: 92-94,96,98-100,995,999)
BG.Public	Percentage of public land use (dor_uc: 83,85-91)
BG.Recreational	Percentage of recreational land use (dor_uc: 82,97)
BG.SingleFamilyResidential	Percentage of single-family land use (dor_uc: 1)

BG.VCommercial	Percentage of vacant commercial land use (dor_uc: 10)
BG.VIndustrial	Percentage of vacant industrial land use (dor_uc: 40)
BG.VInstitutional	Percentage of vacant institutional land use (dor_uc: 70)
BG.VPublic	Percentage of vacant public land use (dor_uc: 80)
BG.VResidential	Percentage of vacant residential land use (dor_uc: 0)
BG.Water	Percentage of water land use (dor_uc: 95)
BG.Landmix	Land-use in computed as $\frac{-\sum_k p_k \ln(p_k)}{\ln(N)}$, where $\boldsymbol{k}$ is the category of land-use, $\boldsymbol{p}$ is the proportion of the land area category, $\boldsymbol{N}$ is the number of land-use categories within a block group
BG.FLD_A	Percentage of flood zone A in a block group
BG.FLD_AE	Percentage of flood zone AE
BG.FLD_AH	Percentage of flood zone AH
BG.FLD_AO	Percentage of flood zone AO
BG.FLD_VE	Percentage of flood zone VE
BG.FLD_SFHA	Percentage of special flood hazard area including zone A, AE, AH, AO, VE. SFHA are areas having a 1 or more-percent chance of being inundated by the flood in any given year
BG.FLD_X	Percentage of areas with flood risk between 0.2-1.0%
BG.FLD_X1	Percentage of areas with flood risk
BG.FLD_WATER	Percentage of water
BG.FLD_OTHER	Percentage of areas not included above categories
Census Tract File (Resolution: Census Tract)	
Field Name	**Definition**
CT.ID	Census tract geoid
CNTY.ID	Corresponding county geoid
CT.Area	Census tract area in acre
CT.Population	Population
CT.Pop_density	Population density (per acre)
CT.Hispanic	Percentage of Hispanic population
CT.White	Percentage of White population
CT.Black_American	Percentage of Black/African American population
CT.Asian	Percentage of Asian population
CT.Other_Race	Percentage of Other races
CT.HH	Number of occupied households
CT.HH_density	Occupied household density (per acre)
CT.No_veh	Percentage of 0-vehicle households
CT.Veh1	Percentage of 1-vehicle households
CT.Veh2	Percentage of 2-vehicle households
CT.Veh3plus	Percentage of 3 or 3+ vehicle households
CT.Income	Median income (USD)
CT.INC2	Median income (thousand USD)
CT.AllVacant	Percentage of vacant land use (dor_uc: 0,10,40,70,80)
CT.Commercial	Percentage of commercial land use (dor_uc: 11-39)
CT.Industrial	Percentage of industrial land use (dor_uc: 41-49)
CT.Institutional	Percentage of institutional land use (dor_uc: 71-79,81,84)
CT.MixedUse	Percentage of mixed-use land use (dor_uc: 12)
CT.MultiFamilyResidential	Percentage of multi-family residential land use (dor_uc: 3,8)
CT.Office	Percentage of office land use (dor_uc: 17,18,19,23,24)

CT.OtherResidential	Percentage of other residential land use (dor_uc: 2,4,7,9)
CT.Others	Percentage of other land use (dor_uc: 92-94,96,98-100,995,999)
CT.Public	Percentage of public land use (dor_uc: 83,85-91)
CT.Recreational	Percentage of recreational land use (dor_uc: 82,97)
CT.SingleFamilyResidential	Percentage of single-family land use (dor_uc: 1)
CT.VCommercial	Percentage of vacant commercial land use (dor_uc: 10)
CT.VIndustrial	Percentage of vacant industrial land use (dor_uc: 40)
CT.VInstitutional	Percentage of vacant institutional land use (dor_uc: 70)
CT.VPublic	Percentage of vacant public land use (dor_uc: 80)
CT.VResidential	Percentage of vacant residential land use (dor_uc: 0)
CT.Water	Percentage of water land use (dor_uc: 95)
CT.Landmix	Land-use in computed as $\frac{-\sum_k p_k \ln(p_k)}{\ln(N)}$, where $\boldsymbol{k}$ is the category of land-use, $\boldsymbol{p}$ is the proportion of the land area category, $\boldsymbol{N}$ is the number of land-use categories within a census tract
County File (Resolution: County)	
Field Name	**Definition**
CNTY.ID	County geoid
CNTY.Area	County area in acre
CNTY.Population	Population
CNTY.Pop_density	Population density (per acre)
CNTY.Hispanic	Percentage of Hispanic population
CNTY.White	Percentage of White population
CNTY.Black_American	Percentage of Black/African American population
CNTY.Asian	Percentage of Asian population
CNTY.Other_Race	Percentage of Other races
CNTY.HH	Number of occupied households
CNTY.HH_density	Occupied household density (per acre)
CNTY.No_veh	Percentage of 0-vehicle households
CNTY.Veh1	Percentage of 1-vehicle households
CNTY.Veh2	Percentage of 2-vehicle households
CNTY.Veh3plus	Percentage of 3 or 3+ vehicle households
CNTY.Income	Median income (USD)
CNTY.INC2	Median income (thousand USD)
CNTY.Jobs	Number of jobs
CNTY.Job_density	Job density (per acre)
CNTY.business	Number of businesses
CNTY.busns_density	Business density (per acre)
CNTY.JobPerc_Accommodation	Percentage of jobs in accommodation industry
CNTY.JobPerc_Administrative	Percentage of jobs in **administrative** services
CNTY.JobPerc_Government	Percentage of jobs in **government services**
CNTY.JobPerc_HealthCare	Percentage of jobs in health care industry
CNTY.JobPerc_OtherServices	Percentage of jobs in other services
CNTY.JobPerc_Professional	Percentage of jobs in professional services
CNTY.JobPerc_RealEstate	Percentage of jobs in real-estate industry
CNTY.JobPerc_Retail	Percentage of jobs in retail industry
CNTY.JobPerc_Finance	Percentage of jobs in finance industry
CNTY.JobPerc_Construction	Percentage of jobs in construction industry
CNTY.JobPerc_Transportation	Percentage of jobs in transportation industry

CNTY.JobPerc_Manufacturing	Percentage of jobs in manufacturing industry
CNTY.JobPerc_Wholesale	Percentage of jobs in wholesale industry
CNTY.JobPerc_Entertainment	Percentage of jobs in entertainment industry
CNTY.JobPerc_Educational	Percentage of jobs in educational industry
CNTY.JobPerc_Information	Percentage of jobs in information industry
CNTY.JobPerc_Management	Percentage of jobs in management industry
CNTY.JobPerc_Farm	Percentage of jobs in farming industry
CNTY.JobPerc_Forestry	Percentage of jobs in forestry
CNTY.JobPerc_Utilities	Percentage of jobs in utility services
CNTY.JobPerc_Mining	Percentage of jobs in mining industry
CNTY.Agricultural	Percentage of agricultural land use (dor_uc: 50-69)
CNTY.AllVacant	Percentage of vacant land use (dor_uc: 0,10,40,70,80)
CNTY.Commercial	Percentage of commercial land use (dor_uc: 11-39)
CNTY.Industrial	Percentage of industrial land use (dor_uc: 41-49)
CNTY.Institutional	Percentage of institutional land use (dor_uc: 71-79,81,84)
CNTY.MixedUse	Percentage of mixed-use land use (dor_uc: 12)
CNTY.MultiFamilyResidential	Percentage of multi-family residential land use (dor_uc: 3,8)
CNTY.Office	Percentage of office land use (dor_uc: 17,18,19,23,24)
CNTY.OtherResidential	Percentage of other residential land use (dor_uc: 2,4,7,9)
CNTY.Others	Percentage of other land use (dor_uc: 92-94,96,98-100,995,999)
CNTY.Public	Percentage of public land use (dor_uc: 83,85-91)
CNTY.Recreational	Percentage of recreational land use (dor_uc: 82,97)
CNTY.SingleFamilyResidential	Percentage of single-family land use (dor_uc: 1)
CNTY.VCommercial	Percentage of vacant commercial land use (dor_uc: 10)
CNTY.VIndustrial	Percentage of vacant industrial land use (dor_uc: 40)
CNTY.VInstitutional	Percentage of vacant institutional land use (dor_uc: 70)
CNTY.VPublic	Percentage of vacant public land use (dor_uc: 80)
CNTY.VResidential	Percentage of vacant residential land use (dor_uc: 0)
CNTY.Water	Percentage of water land use (dor_uc: 95)
CNTY.Landmix	Land-use in computed as $\frac{-\sum_k p_k \ln(p_k)}{\ln(N)}$, where $\boldsymbol{k}$ is the category of land-use, $\boldsymbol{p}$ is the proportion of the land area category, $\boldsymbol{N}$ is the number of land-use categories within a county

11 CONCLUSION

In this report, the research team presented a summary of the tasks undertaken by the research team. The report documents the model framework, forecasting procedure and future forecasts generated for the three variable groups including sociodemographic, land use and economic development variables. The research team has employed a series of statistical and data driven approaches to train the components of the proposed framework. From the estimated model systems, we observe interdependencies between the variables considered. To be exact, a change in one variable in a year may affect other variables in the following year. Based on the estimated models, we forecast the variables for each year in the forecasting period (2021-2050). For parcel land use forecasting, we follow a microsimulation technique where new land use type is chosen based on a probabilistic assignment using probabilities suggested by the model components. Parcel level land use is then aggregated to generate land use distribution at various spatial resolutions (such as parcel, census block group and county). The data at multiple resolutions will facilitate the data product adoption across different jurisdictions.

In this report, we also presented comparisons between different variables to check for consistency of the forecasted data. From the analysis, it is evident that forecasted variables are consistent with trends observed from the historical data. Finally, we provide a detailed instruction how to use the delivered datafiles while datafiles are in two commonly used formats (.csv and .shp).

Finally, it is important to highlight that the land use data at the various spatial resolutions is generated based on observed patterns from different sources including U.S. Census Bureau and American Community Survey, Florida Department of Revenue, Florida Geographic Data Library, American Community Survey and Bureau of Economic Analysis. It is important to note that we were not able to incorporate jurisdiction specific requirements on zoning and other local planning elements in the analysis for statewide data generation. Thus, the user should recognize that the overall motivation for the project is the development of land use pattern projections for different parts of the state. The objective of the data generated is not to suggest or propose a land use type for a specific parcel in the future. The data outputs provided need to be adopted as an overall estimated future pattern (given the observed patterns so far) as opposed to suggested land use pattern evolution.

12 APPENDIX

12.1 Stakeholder Survey

12.1.1 IRB Approval Letter

UCF

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138, IRB00012110
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

December 16, 2022

Dear Naveen Eluru:

On 12/16/2022, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study
Title:	Development of a High-resolution Statewide Socio-demographic, Land Use and Economic Development Framework for Transportation Planning
Investigator:	Naveen Eluru
IRB ID:	STUDY00004969
Funding:	Name: Florida Department of Transportation (FDOT), Funding Source ID: BED26 TWO 977-02
Grant ID:	
Documents Reviewed:	• CITI_Kazi.pdf, Category: Other; • CITI_Lauren.pdf, Category: Other; • CITI_Sudipta.pdf, Category: Other; • CITI_Youssef.pdf, Category: Other; • Consent Form_updated.pdf, Category: Consent Form; • Email script_updated.docx, Category: Recruitment Materials; • Protocol_updated.docx, Category: IRB Protocol; • Research Project Survey_updated.docx, Category: Survey / Questionnaire;

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please submit a modification request to the IRB. Guidance on submitting Modifications and Administrative Check-in are detailed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

Page 1 of 2

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Kristin Badillo
Designated Reviewer

12.1.2 Survey Consent Form

UNIVERSITY OF CENTRAL FLORIDA

EXPLANATION OF RESEARCH

Project Title: Development of a High-resolution Statewide Socio-demographic, Land Use and Economic Development Framework for Transportation Planning

Principal Investigator: Naveen Eluru

You are being invited to take part in a research study and your participation is voluntary. Your participation is valuable to our research efforts. Whether you take part is up to you.

This research is geared towards developing a standardized high resolution state-wide sociodemographic, land use and economic development model that will provide stakeholders with a framework analogous to the Florida Standard Urban Transportation Model Structure (FSUTMS) model.

As a part of this study, our research team is working on evaluating the importance of different input variables employed in transportation planning models. The groups of variables considered in this study include socio-demographic, land use and economic development variables. In this online survey, you will be asked to assign relative weights for each variable group pair (e.g., socio-demographics vs. land use). You will also be asked to select important variables provided under each group (e.g., population, vehicle ownership under socio-demographic variables). It will take you approximately 5-10 minutes to complete the survey.

No personal identifiable information will be collected in the survey. Aggregated results of this survey will be used for this research project and publication in scientific journals, but you will not be identifiable in any communications resulting from this study. All information will be stored on computers that are protected using passwords and only the research team members will have the data access. The survey data will be stored for 5 years after the study closure.
You can refuse to participate or can withdraw from this study at any time for any reason. However, please note that if you close the browser tab your partial responses will be recorded. Refusal to participate or your withdrawal from the study will not involve any penalty.

The intended population for this survey is FDOT stakeholders (professionals from various districts, Turnpike, FDOT statewide model building personnel, consultants in the planning field and Florida Model Task Force members). You must be at least 18 years of age to take part in the survey.

If you have any questions and/or comments and/or would like to know about the study findings, feel free to contact the principal investigator of the project: Naveen Eluru (naveen.eluru@ucf.edu), Professor, University of Central Florida, Orlando, USA.
If you have questions about your rights as a research participant, or have concerns about the conduct of this study, please contact Institutional Review Board (IRB), University of Central Florida, Office of Research, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901, or email irb@ucf.edu.

The researchers have no conflicts of interest in this study.

12.1.3 Survey Document

Start of Block: Consent Form

Study Objectives and Details

Text from "Explanation of Research Form"

End of Block: Consent Form

Start of Block: Terms and Conditions

Before proceeding, please carefully read the consent form provided in the first page.

Do you agree to the terms and conditions provided in the first page? By clicking Yes, you consent that you are willing to answer the questions in this survey.

- ◯ Yes
- ◯ No

End of Block: Terms and Conditions

Start of Block: Survey Instructions

Before you begin, please read the following paragraph carefully.

Toward evaluating usefulness of input variables, scoring/ranking them is a useful step. In our research, three groups of variables have been considered. These three groups considered are presented below:

Socio-demographic variables: Population, Number of households, Age distribution, Gender, Number of children, School enrollment and Vehicle ownership

Land use characteristics: Land use mix/diversity variable, Recreational area and Number of hotel/motels

Economic development indicators: Median income, Employment, Average number of workers per household, Retail/shopping center density

End of Block: Survey Instructions

Start of Block: Pairwise Comparison Instructions

In this study, we intend to adopt a 'Pairwise Comparison' method for scoring variable groups. In this approach, we compare variable group A with variable group B on a reciprocal numerical rating scale ranging from 1/9 (extreme preference for group B) to 9 (extreme preference for group A). Numerical scale for preference rating is given below:

Preference Rating	Definition
1	Equal importance
2	Weak or slightly important
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very, very strong
9	Extreme importance

End of Block: Pairwise Comparison Instructions

Start of Block: Pairwise Comparison Example

For example, variable group A has moderate preference over variable group B. As a result, decision-maker can assign a numerical score 3 to A compared to B. According to this methodology, preference rating of B compared to A will be reciprocal of 3. A demonstration of pairwise relationships for three variable groups is provided in following table:

Variable Group	Socio-demographics	Land use	Economic development
Socio-demographics	1	3	4
Land use	1/3	1	2
Economic development	1/4	1/2	1

Overall weights for the variable groups can be computed from processing the pairwise comparison matrix above.

End of Block: Pairwise Comparison Example

Start of Block: Pairwise Comparison Question

1. Provide a relative score for “socio-demographic variables" (between 1/9 and 9) compared to land use and economic development variables.

	Land use	Economic development
Socio-demographics		

2. Provide a relative score for “land use variables" (between 1/9 and 9) compared to economic development variables.

	Economic development
Land use	

End of Block: Pairwise Comparison Question

Start of Block: Variable importance instructions

In the next step, we intend to choose important variables within each variable group. In the following pages, you will be requested to select variables from a variable list.

Please proceed to the next page.

End of Block: Variable importance instructions

Start of Block: Socio-demographic variables

1. Please choose important **socio-demographic variables** from the following list (select all that apply):

- ☐ Population
- ☐ Number of households
- ☐ Age distribution
- ☐ Gender distribution
- ☐ Race
- ☐ Number of children
- ☐ School enrollment
- ☐ Educational Status
- ☐ Vehicle ownership
- ☐ Other (please specify) ____

2. Please choose **must-have socio-demographic variables** from the important variables you selected in the following list (select all that apply): (Options will be based on answer to Q1 e.g., "other (please specify)" option will be available if respondents choose that option in Q1)

- ☐ Population
- ☐ Number of households
- ☐ Age distribution
- ☐ Vehicle ownership
- ☐ Other (please specify)

End of Block: Socio-demographic variables

Start of Block: Land use variables

3. Please choose important **land use variables** for transportation planning models from the following list:

- ☐ Land use mix / Land use diversity variable
- ☐ Residential area
- ☐ Business center density
- ☐ Institutional area
- ☐ Roadway density
- ☐ Railway density
- ☐ Bike lane density
- ☐ Sidewalk density
- ☐ Bus station and network density
- ☐ Metro station density
- ☐ Accessibility to jobs
- ☐ Number of hotel/motels
- ☐ Other (please specify)

____

4. Please choose **must-have land use variables** from the important variables you selected in the following list (select all that apply): (Options will be based on answer of Q3)

- [ ] Land use mix / Land use diversity variable
- [ ] Residential area
- [ ] Business center density
- [ ] Institutional area
- [ ] Other (please specify)

End of Block: Land use variables

Start of Block: Economic development variables

5. Please choose important **economic development variables** for transportation planning models from the following list:

- [ ] Median income
- [ ] Employment
- [ ] Retail employment density
- [ ] Population-employment balance
- [ ] Average number of workers per household
- [ ] Retail density
- [ ] Shopping center density
- [ ] Other (please specify)

---

6. Please choose **must-have economic development variables** from the important variables you selected in the following list (select all that apply): (Options will be based on answer of Q5)

- [ ] Median income
- [ ] Employment
- [ ] Retail employment density
- [ ] Population-employment balance
- [ ] Other (please specify)

End of Block: Economic development variables

Start of Block: User Information

1. What sector are you employed in?

- [ ] Public Sector
- [ ] Private Sector

---

2. Which of these agencies do you work for? (This question is only for public sector employees)

- ○ Florida Department of Transportation (FDOT)
- ○ Metropolitan Planning Organization (MPO)
- ○ Metropolitan Transportation Plan (MTP)
- ○ Central Florida Expressway Authority (CFX)
- ○ Miami-Dade Expressway Authority (MDX)
- ○ Tampa Hillsborough Expressway Authority (THEA)
- ○ Other (please specify)

2. Please specify the agency you work for: (This question is only for private sector employees)

3. How long have you been in the transportation industry?

- ○ Less than 2 years
- ○ 2-5 years
- ○ 5-10 years
- ○ More than 10 years

12.1.4 Survey Link and QR Code

Survey Link: https://ucf.qualtrics.com/jfe/form/SV_0oAB16OXnOX9d2u

QR Code:

12.2 Land Use Models

12.2.1 Agricultural Land Use

Table 30 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-4.291	-41.011
% Black/African American	0.006	4.576
Median Income (thousand)	0.006	6.176
% Vacant Land Use in BG	0.0126	10.715
% Commercial Land Use	0.032	7.201
% Other Residential Land Use	0.019	4.672
% Other Land Use	0.032	18.145
% Public Land Use	0.013	9.656
% Single-family Residential	0.014	8.034
Ln(Parcel Area in acre)	-0.156	-17.181
% Low Flood Risk in BG	0.003	4.282

Table 31 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	-0.216	10.164
Population (in thousands)	-0.043	-7.069
Jobs (in thousands)	0.0004	6.495
% Hispanic	0.014	13.074
% Asian	0.027	4.510
% 0-Vehicle Households	0.026	6.980
Median Income (in thousands)	0.011	12.115
% Vacant Land Use in BG	-0.005	-6.146
% Multi-family Residential	-0.051	-4.396
% Office Land Use	-0.091	-5.068
% Other Land Use	-0.020	-15.946
% Recreational Land Use	-0.006	-4.711
Land Use Mix	1.208	12.571
Ln(Parcel Area in acre)	-0.199	-26.304

Table 32 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.179	-1.263
% White	-0.006	-5.680
% Black/African American	-0.009	-5.834
% Asian	-0.024	-3.220

Households (in thousands)	0.059	5.334
Median Income (in thousands)	0.005	5.047
% Agricultural Land Use	-0.011	-11.923
% Commercial Land Use	-0.023	-4.484
% Institutional Land Use	-0.014	-3.265
% Other Residential	-0.020	-5.423
% Other Land Use	0.014	7.562
% Public Land Use	-0.015	-10.940
% Recreational Land Use	-0.012	-7.267
% Single-family Residential	-0.023	-10.588

Table 33 MNL Model of New Land Use Type (Base: Vacant Residential)

Variables	Others		Single-family Residential		Other Residential		Public		Low Share Categories	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-1.610	-31.112	-0.085	-7.376	-1.021	-17.814	-3.492	-27.497	-3.236	-32.489
Population density	--	--	-0.276	-10.647	-0.149	-4.266	--	--	--	--
% Hispanic	--	--	-0.010	-10.531	-0.011	-7.178	--	--	--	--
% Black/African American	0.024	25.805	--	--	0.006	4.417	--	--	0.009	5.719
% 3/3+ Vehicle Households	-0.032	-15.216	0.007	3.199	--	--	--	--	-0.038	-11.818
Median income (thousands)	0.013	14.632	-0.003	-3.523	--	--	0.005	2.585	0.012	8.758
Job density	--	--	0.353	7.181	--	--	-0.407	-3.469	0.529	9.070
% Vacant Land Use	0.011	11.914	-0.013	-11.568	-0.019	-11.206	-0.039	-11.635	0.005	3.232
% Industrial Land Use	--	--	0.026	3.908	--	--	--	--	0.078	13.654
% Mixed Use Land Use	-0.404	-5.757	-0.180	-3.096	--	--	0.394	4.625	--	--
% Multi-family Residential	--	--	0.131	8.874	--	--	0.110	4.034	0.157	11.020
% Other Residential	--	--	--	--	0.083	20.271	-0.063	-6.144	-0.015	-3.032
% Single-family Residential	-0.055	-26.876	0.020	11.943	-0.030	-9.492	-0.064	-11.999	-0.015	-6.724
Land Use Mix	1.819	14.113	-0.842	-6.746	-0.508	-2.871	3.308	11.573	1.877	9.271
Ln(Parcel Area in acre)	0.461	46.984	0.212	22.837	0.245	19.240	0.455	22.604	0.496	34.026

12.2.2 Commercial Land Use

Table 34 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-3.777	-38.589
Population Density	-0.049	-9.360
% Hispanic	-0.014	-12.407
% 0-Vehicle Households	0.012	6.141
Job Density	0.482	13.909
% Commercial Land Use	-0.009	-5.816
% Mixed Use Land Use	-0.052	-4.045
Land Use Mix	0.499	3.976
Ln(Parcel Area in acre)	-0.270	-27.186
% Low flood risk zone	0.002	4.941

Table 35 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	1.238	5.983
% Hispanic	0.017	17.165
% Asian	-0.028	-6.449
Household Density	0.238	15.342
% 0-Vehicle Households	-0.020	-10.350
Job Density	-0.459	-13.491
% Agricultural Land Use	-0.010	-8.250
% Commercial Land Use	-0.006	-3.479
% Institutional Land Use	-0.014	-5.221
% Multi-family Residential	-0.008	-2.893
% Office Land Use	-0.019	-5.393
% Other Residential	-0.026	-12.756
% Public Land Use	-0.008	-5.820
% Recreational Land Use	-0.026	-10.555
% Single-family Residential	-0.016	-14.230
Land Use Mix	-0.466	-3.506
Ln(Parcel Area in acre)	0.203	23.192

Table 36 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.355	-3.551
% White	-0.010	-10.546
% Black/African American	-0.012	-10.464
Number of households (thousand)	0.045	4.831

% 0-Vehicle Households	-0.007	-2.832
% Commercial Land Use	-0.007	-4.402
% Industrial Land Use	-0.021	-11.348
% Institutional Land Use	-0.018	-5.596
% Mixed Use Land Use	0.026	3.091
% Multi-family Residential	-0.009	-3.953
% Office Land Use	-0.016	-5.848
% Other Land Use	-0.008	-4.094
% Public Land Use	-0.007	-5.815
% Recreational Land Use	-0.007	-2.868
% Single-family Residential	-0.015	-17.407
Ln(Parcel Area in acre)	-0.067	-7.298

Table 37 MNL Model of New Land Use Type (Base: Vacant Commercial)

Variables	Office		Industrial		SF Residential		Other Residential		Mixed Use		Vacant Residential		Institutional		Public		Low Share Category	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-1.15	-9.78	-1.19	-13.75	-1.29	-8.32	-1.08	-6.48	-1.53	-15.08	-1.45	-10.44	-1.90	-13.78	-1.72	-18.03	-0.62	-10.97
% Hispanic	-0.01	-6.19	--	--	-0.03	-13.00	-0.02	-9.01	--	--	-0.01	-5.22	-0.01	-4.36	-0.01	-4.22	--	--
% Asian	-0.01	-2.64	--	--	--	--	--	--	-0.08	-6.23	-0.07	-5.35	--	--	--	--	-0.03	-4.55
Median Income	0.00	-2.67	-0.01	-6.54	-0.01	-5.77	0.01	9.96	--	--	0.01	4.83	-0.01	-6.15	--	--	0.01	5.45
Job Density	-0.35	-7.45	0.21	4.19	--	--	--	--	-0.49	-7.64	-0.33	-4.50	--	--	-0.41	-5.34	--	--
%Agricultural	--	--	0.01	5.84	0.01	9.41	--	--	--	--	0.01	7.63	0.01	3.74	0.01	5.62	--	--
% Industrial	0.02	7.53	0.07	26.95	--	--	-0.04	-7.08	--	--	--	--	0.02	3.58	--	--	0.02	7.21
% Institutional	0.02	4.05	0.01	3.44	--	--	-0.04	-5.59	--	--	--	--	0.05	13.60	--	--	--	--
% Office	0.08	19.45	--	--	-0.03	-4.42	--	--	--	--	-0.10	-7.56	--	--	--	--	-0.04	-7.30
% Public	0.01	4.22	--	--	0.01	4.62	--	--	0.01	4.81	0.01	4.50	0.01	4.91	0.03	13.02	--	--
% Single-family Residential	0.02	17.41	0.01	8.30	0.02	15.86	-0.02	-11.70	0.01	7.76	--	--	0.02	11.05	0.01	4.40	--	--
Ln(Parcel Area)	-0.09	-6.72	0.09	5.86	-0.15	-9.23	-0.20	-13.42	-0.14	-7.47	-0.08	-4.33	0.08	3.69	0.13	6.42	0.06	4.62

12.2.3 Industrial Land Use

Table 38 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t statistic
Constant	-5.313	-62.920
Household density	-0.360	-17.170
Job density	0.695	18.630
% White	0.011	14.960
% 0 vehicle households	0.025	11.270
% Agricultural Land Use	0.014	14.590
% Institutional Land Use	0.026	13.510
% Single Family Residential Land Use	0.017	16.120
Ln(Parcel Area in acre)	-0.305	-34.130
% Low Flood Risk Zone	0.006	10.990

Table 39 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t statistic
Constant	-0.937	-12.453
Population (in thousands)	-0.192	-12.393
Jobs (in thousands)	0.001	15.370
% Hispanic	0.018	11.439
Median Income (in thousands)	0.004	3.331
% Agricultural land Use	0.014	11.166
% Mixed Use Land Use	0.150	6.945
Ln(Parcel Area in acre)	0.435	29.733

Table 40 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t statistic
Constant	-1.137	-11.240
% 0 Vehicle Households	-0.007	-2.065
% 3+ Vehicle Households	0.024	7.119
% Agricultural Land Use	-0.008	-5.469
% Industrial Land Use	-0.014	-7.568
% Institutional Land Use	-0.027	-10.613
% Mixed Use Land Use	0.107	5.613
% Office Land Use	-0.012	-2.584
% Other Land Use	-0.031	-5.242
% Public Land Use	-0.010	-3.525
% Recreational Land Use	-0.008	-4.451
% Single-family Residential	-0.022	-12.351

Table 41 MNL Model of New Land Use Type (Base: Commercial)

Variable	Vacant Commercial		Vacant Industrial		Vacant Residential		Single-Family Residential		Others		Office		Public		Low Share Category	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-0.716	-8.026	-3.984	-20.521	-4.285	-27.217	-3.826	-20.351	-2.471	-13.682	-1.342	-24.640	-3.379	-11.719	-1.275	-12.690
% Asian	--	--	0.060	9.328	-0.033	-3.166	--	--	0.052	5.341	0.042	4.907	0.058	5.796	--	--
Job Density	-0.628	-9.460	--	--	0.988	10.574	--	--	-0.656	-5.644	--	--	-0.471	-4.080	0.281	4.007
% Agricultural	0.012	5.315	0.052	17.746	0.064	25.848	0.048	15.008	0.042	14.723	--	--	0.036	9.217	0.030	14.146
% Vacant	0.032	13.013	0.038	10.896	--	--	--	--	--	--	--	--	0.026	4.925	0.024	9.368
% Industrial	--	--	0.052	17.561	--	--	0.034	8.111	0.048	12.975	--	--	0.024	4.742	--	--
% Institutional	--	--	0.078	15.328	0.072	13.765	0.058	8.909	0.028	2.594	--	--	--	--	0.026	4.430
% Public	--	--	0.019	5.826	0.049	18.905	0.024	6.029	--	--	--	--	0.052	13.936	--	--
% Recreational	-0.033	-4.272	0.043	12.059	--	--	--	--	0.044	12.245	--	--	0.040	8.677	0.012	3.359
% SF Residential	--	--	0.019	6.926	0.050	22.799	0.047	16.766	0.013	3.368	--	--	0.018	4.187	--	--
Ln(Parcel Area)	-0.235	-13.104	-0.408	-20.400	0.111	4.934	-0.142	-5.565	0.283	10.579	--	--	--	--	0.123	6.589

12.2.4 Institutional Land Use

Table 42 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t statistic
Constant	-4.977	-26.092
Population (thousand) at block group	0.032	6.576
% Hispanic	0.007	9.432
% Asian and other race	0.039	16.635
% 0, 1 and 2-vehicle households	0.009	4.467
Median Income (in thousands)	0.017	26.137
% Vacant Land Use	-0.005	-3.545
% Public Land Use	0.005	5.072
% Institutional Land Use	0.012	13.419
% Commercial Land Use	0.003	2.170
Ln(Parcel Area in acre)	-0.082	-18.633
% Low Flood Risk Zone	0.002	3.639

Table 43 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t statistic
Constant	-0.046	-0.518
Population Density	-0.029	-4.564
% Hispanic, Asian and Other Race	0.012	10.509
% 3/3+ Vehicle Households	0.026	8.842
% Agricultural land Use	-0.007	-6.492
% Vacant Land Use	-0.011	-5.970
% Public Land Use	0.016	9.901
% Institutional Land Use	0.030	15.081
% Commercial Land Use	-0.015	-6.801
Ln(Parcel Area in acre)	0.088	9.741

Table 44 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t statistic
Constant	-2.260	-18.514
% White	0.007	7.395
Population Density	-0.023	-2.064
% 2/2+ Vehicle Households	0.007	2.708
Median Income (in thousands)	-0.006	-3.063
% Single-family Residential	-0.006	-4.155
% Vacant Land Use	-0.004	-1.510
% Institutional Land Use	-0.006	-1.931

Table 45 MNL Model of New Land Use Type (Base: Vacant Residential)

Variable	SF Residential		Other Residential		Public		Vacant Commercial		Commercial		Vacant Institutional		Others		Low Share Category	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-2.226	-20.617	-3.461	-20.542	-1.623	-11.830	-0.095	-0.709	-1.492	-10.787	-1.776	-9.298	0.740	5.526	-1.001	-12.803
Population Density	--	--	--	--	-0.054	-4.239	--	--	--	--	-0.053	-2.959	--	--	--	--
% White	-0.005	-5.291	0.015	9.095	--	--	-0.003	-2.374	--	--	-0.012	-6.351	-0.026	-16.279	--	--
% 3/3+ Vehicle	-0.023	-5.748	-0.015	-2.535	-0.056	-10.930	-0.029	-4.266	-0.047	-6.534	-0.019	-2.808	-0.019	-3.231	-0.053	-11.640
Ln(Parcel Area)	-0.096	-8.115	-0.154	-9.575	0.094	6.362	--	--	0.079	3.739	0.147	6.005	--	--	0.123	8.335
Median Income	--	--	--	--	0.027	19.379	-0.016	-6.696	-0.007	-2.839	--	--	--	--	--	--
% Agricultural	0.027	17.257	0.016	7.358	0.007	4.100	-0.012	-4.331	--	--	--	--	--	--	0.018	12.814
% Vacant	0.095	28.971	0.079	19.617	0.032	7.185	0.054	12.932	0.074	17.715	0.085	21.058	-0.016	-2.601	0.073	21.629
% SF Residential	0.028	19.060	-0.004	-1.654	-0.012	-5.759	-0.014	-6.291	--	--	0.006	2.279	-0.027	-11.224	--	--

12.2.5 Mixed Land Use

Table 46 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.695	-29.956
Pop Density	-0.023	-7.767
% Hispanic	-0.002	-2.742
% Black/African American	0.004	7.430
% 2/2+ Vehicle Households	-0.003	-3.116
% Other Residential	0.008	4.712
% Public Land Use	-0.002	-2.709
Land Use Mix	0.391	4.275
Ln(Parcel Area in acre)	-0.060	-7.024
% Low flood risk zone	0.002	5.454

Table 47 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.674	4.974
Household Density	0.084	3.300
% Hispanic	0.018	9.429
% Black/African American	0.006	4.137
% 2/2+ Vehicle Households	0.015	5.269
Median Income (in thousands)	-0.011	-4.980
Job Density	-0.340	-5.288
% Agricultural land Use	-0.006	-3.488
% Other Residential	-0.024	-6.371
% Multi-family Residential	-0.011	-1.975
Ln(Parcel Area in acre)	0.308	14.421

Table 48 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.749	-10.183
% Hispanic	0.010	4.777
% Black/African American	-0.006	-3.713
% 2/2+ Vehicle Households	0.006	2.115
Median Income (in thousands)	-0.006	-2.352
Job Density	-0.293	-3.826
% Agricultural Land Use	0.005	2.255
% Public land Use	-0.005	-1.659
% Other Residential	0.010	3.280

Table 49 MNL Model of New Land Use Type (Base: Commercial)

Variable	SF Residential		Vacant Commercial		Office		MF Residential		Other Residential		Industrial		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	-0.052	-0.240	0.114	0.649	-0.550	-4.655	-0.317	-1.015	-4.041	-12.025	-1.184	-4.177	-1.386	-4.103
Population Density	-0.024	-2.147	-0.024	-2.149	-0.027	-2.463	--	--	0.036	1.818	-0.097	-4.678	0.020	1.779
% Hispanic	-0.012	-5.108	-0.013	-5.444	-0.009	-3.563	-0.016	-4.529	-0.035	-5.910	--	--	-0.013	-5.010
% Black/African American	0.006	3.979	-0.005	-2.863	--	--	-0.006	-2.259	--	--	--	--	--	--
% 2/2+ Vehicle HHs	0.010	2.689	--	--	--	--	-0.018	-3.811	0.019	3.052	0.018	2.927	0.010	2.216
Median Income	-0.013	-4.164	-0.011	-4.561	--	--	--	--	0.016	4.207	-0.029	-5.202	-0.005	-1.654
Job Density	--	--	--	--	0.471	5.981	--	--	-0.544	-3.398	0.677	5.474	--	--
Land Use mix	--	--	--	--	--	--	--	--	--	--	--	--	0.665	1.906
Ln(Parcel Area)	-0.114	-3.831	-0.060	-1.984	-0.075	-2.244	-0.093	-1.994	-0.506	-11.984	0.259	5.687	0.095	2.837
% Commercial	-0.022	-4.640	-0.007	-1.678	-0.013	-2.814	-0.029	-3.712	--	--	--	--	-0.019	-3.204
% Agriculture	0.011	4.254	0.006	1.941	-0.012	-2.874	--	--	0.026	7.157	--	--	0.021	7.217
% Public Land Use	-0.025	-7.021	--	--	-0.009	-2.681	-0.014	-2.772	--	--	--	--	--	--
% Vacant Land Use	0.016	4.799	0.019	5.444	--	--	0.012	2.236	0.015	2.536	0.012	2.142	0.014	3.371

12.2.6 Multi-family Residential

Table 50 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-0.244	-0.953
Household Density	-0.244	-14.726
% Hispanic	-0.022	-19.713
% Black/African American	-0.006	-7.764
% 1-Vehicle Households	-0.030	-9.926
% 2-Vehicle Households	-0.026	-9.586
% 3/3+ Vehicle Households	-0.025	-6.653
Job Density	0.650	17.630
% Multi-family Residential	-0.016	-7.303
Land Use Mix	-0.639	-5.317
Ln(Parcel Area in acre)	-0.442	-23.832
% Highest Flood Risk Zone	-0.004	-7.286

Table 51 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	-2.945	-12.587
Household Density	0.164	12.408
% Hispanic	0.024	25.757
% Black/African American	0.004	5.486
% 1-vehicle	0.015	5.439
% 2-vehicle	0.030	10.757
% 3+ vehicle	0.032	9.306
Median Income	0.003	2.928
Job Density	-0.298	-8.633
% Vacant Land Use	0.017	13.552
% Multi-Family Residential	-0.010	-5.072
% Other Residential	0.009	4.747
% Commercial Land Use	0.010	5.950
Ln(Parcel Area in acre)	0.464	36.173

Table 52 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.150	-17.206
% Hispanic	-0.006	-6.074
% Black/African American	-0.005	-8.993
% 0-vehicle Households	-0.032	-16.018
Median Income	-0.017	-15.510
Job Density	-0.306	-9.157
% Multi-family Residential	0.003	3.065
Ln(Parcel Area in acre)	-0.266	-19.391

Table 53 MNL Model of New Land Use Type (Base: Singe-family Residential)

Variable	Vacant Residential		Other Residential		Vacant Commercial		Commercial		Low Share Categories	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Intercept	-0.287	-1.476	-6.213	-13.539	-3.792	-15.118	-4.018	-18.380	-1.575	-11.843
Population Density	0.042	10.314	--	--	0.065	10.911	--	--	0.022	4.069
% Hispanic	--	--	--	--	0.008	4.127	--	--	0.005	3.706
% 1-Vehicle HHs	-0.013	-5.069	0.045	8.076	--	--	--	--	--	--
% 2-Vehicle HHs	-0.017	-5.539	0.055	10.435	-0.032	-8.132	--	--	-0.011	-3.702
% 3+ Vehicle HHs	--	--	0.078	12.891	--	--	-0.022	-3.128	--	--
Median Income	-0.006	-4.143	-0.015	-7.982	--	--	0.006	2.731	-0.011	-6.580
Job Density	-0.442	-10.128	-0.392	-6.996	--	--	--	--	-0.339	-7.166
Ln(Parcel Area)	0.221	13.718	0.471	25.193	0.409	13.888	0.197	6.756	0.421	25.003
% Other Residential	0.014	5.150	0.053	22.345	--	--	0.029	7.819	--	--
% Commercial	--	--	0.018	6.132	0.023	6.030	0.036	12.516	-0.011	-3.890
% Vacant	0.024	17.043	--	--	0.037	14.178	--	--	--	--
Land Use Mix	0.472	3.445	0.827	4.643	2.124	7.168	1.468	5.142	2.717	16.963

12.2.7 Office Land Use

Table 54 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t statistic
Constant	-3.595	-74.394
Household density	-0.312	-21.120
% Hispanic	-0.017	-17.092
Job density	1.001	35.092
% Agricultural Land Use	0.005	5.060
% Multi-Family Residential Land Use	0.022	11.406
% Other Residential Land Use	0.016	10.363
% Single Family Residential Land Use	0.003	5.138
Ln(Parcel Area in acre)	-0.213	-36.880
% Low Flood Risk Zone	0.002	5.442

Table 55 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t statistic
Constant	0.851	11.503
Household density	0.303	14.203
% Hispanic	0.015	11.417
% Asian	-0.051	-8.806
Median Income (in thousands)	-0.007	-6.015
Job density	-0.692	-14.992
% Institutional Land Use	-0.022	-7.330
% Multi-Family Residential Land Use	-0.024	-8.059
% Office Land Use	-0.022	-6.620
% Other Residential Land Use	-0.023	-8.587
% Recreational Land Use	-0.034	-7.597
% Single Family Residential Land Use	-0.012	-11.635
Ln(Parcel Area in acre)	0.433	34.019

Table 56 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t statistic
Constant	-0.897	-11.967
% Hispanic	0.013	13.683
% Black/African American	-0.005	-5.823
% Asian	-0.025	-7.266
Households (in thousands)	-0.085	-5.802
% 0 Vehicle Households	-0.014	-6.605
Median Income (in thousands)	-0.005	-5.861
% Industrial Land Use	-0.018	-9.440
% Institutional Land Use	-0.010	-6.914
% Multi-Family Residential Land Use	-0.018	-9.131

% Public Land Use	-0.005	-4.925
% Recreational Land Use	-0.020	-9.067
% Single-family Residential	-0.014	-19.993
Ln(Parcel Area in acre)	-0.148	-14.084

Table 57 MNL Model of New Land Use Type (Base: Vacant Commercial)

Variable	Commercial		Single-family Residential		Institutional		Other Residential		Industrial		Low Share Category	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	4.007	26.367	3.781	24.854	1.751	11.162	0.549	3.942	6.416	25.360	4.655	21.220
% Hispanic	--	--	-0.019	-7.451	0.010	5.282	--	--	--	--	-0.007	-3.968
% Black/African American	-0.004	-3.351	--	--	--	--	-0.006	-2.655	--	--	-0.006	-4.342
% Asian	-0.035	-6.548	--	--	-0.022	-2.900	--	--	--	--	-0.052	-8.092
Median Income (in thousand)	-0.027	-19.051	-0.040	-20.238	-0.011	-6.140	--	--	-0.033	-13.806	-0.016	-10.824
% Agricultural	-0.022	-11.146	-0.020	-8.739	-0.018	-7.539	-0.023	-7.930	-0.041	-14.524	-0.032	-12.888
% Vacant	-0.035	-13.858	-0.053	-14.381	-0.048	-13.223	-0.036	-9.606	-0.064	-15.765	-0.046	-15.192
% Commercial	--	--	-0.018	-5.081	-0.018	-4.792	--	--	-0.056	-10.870	-0.035	-10.619
% Institutional	-0.036	-10.440	-0.023	-5.648	--	--	-0.025	-4.938	-0.064	-10.416	-0.031	-9.363
% MF Residential	-0.025	-8.016	-0.029	-6.346	--	--	-0.021	-4.240	-0.075	-10.531	-0.035	-9.614
% Office	-0.045	-10.831	-0.048	-8.605	-0.039	-6.999	-0.026	-4.657	-0.103	-12.683	-0.051	-11.117
% Other Residential	-0.046	-13.999	-0.084	-13.067	-0.084	-13.326	--	--	-0.105	-14.106	-0.058	-15.410
% Others	-0.033	-9.409	-0.064	-9.378	-0.026	-5.924	-0.034	-6.569	-0.055	-10.112	-0.034	-9.255
% Public	-0.014	-5.982	-0.016	-5.575	--	--	--	--	-0.055	-12.776	-0.017	-6.315
% SF Residential	-0.015	-9.390	--	--	-0.018	-10.349	-0.024	-12.263	-0.054	-19.653	-0.034	-15.324
Ln(Parcel Area)	0.475	32.730	0.470	21.954	0.375	18.319	0.311	14.386	0.627	26.525	0.507	32.243

12.2.8 Other Residential Land Use

Table 58 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-4.212	-28.061
Population Density	-0.074	-7.586
% Hispanic	-0.014	-7.969
% 1/1+ Vehicle Households	0.011	5.650
Median Income (thousands)	0.005	3.361
Land Use Mix	0.691	4.662
% Other Residential	-0.013	-6.923
% Vacant Land Use	-0.007	-4.671
% Single-family Residential	0.006	4.273
% Other Land Use	0.006	2.620
% Public Land Use	0.005	3.352
Ln(Parcel Area in acre)	0.105	9.542

Table 59 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	1.092	21.745
Population Density	0.048	15.029
% Hispanic	0.007	12.939
% Black/African American	0.007	14.507
% 0,1-Vehicle Households	-0.007	-10.502
Median Income (thousands)	-0.003	-5.743
Job Density	-0.945	-46.718
Land Use Mix	-1.427	-29.980
% Other Residential	-0.022	-29.627
% Vacant Land Use	0.002	4.923
% Commercial Land Use	-0.009	-10.683
% Other Land Use	0.014	19.544
% Public Land Use	-0.009	-20.343
Ln(Parcel Area in acre)	0.017	4.470

Table 60 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.020	-22.123
% Hispanic	-0.003	-5.721
% Black/African American	-0.008	-15.604
% Asian	-0.014	-6.346
% 0,1-Vehicle Households	-0.001	-1.930
Median Income (thousands)	-0.005	-9.630
Job Density	-0.254	-15.153

% Vacant Land Use	-0.001	-2.127
% Other Residential	-0.007	-10.980
% Commercial Land Use	-0.012	-16.571
% Public Land Use	-0.006	-15.040
Ln(Parcel Area in acre)	-0.030	-5.910

Table 61 MNL Model of New Land Use Type (Base: Vacant Residential)

Variables	Single-family Residential		Others		Agricultural		Multi-family Residential		Vacant Commercial		Public		Low Share Categories	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	1.312	13.129	-1.625	-6.396	0.424	1.606	2.889	10.898	-5.533	-59.146	-3.553	-38.602	-4.970	-66.758
Population Density	0.076	18.365	0.050	7.305	-0.421	-15.032	0.137	28.421	0.137	28.421	0.117	16.540	0.135	29.252
% Hispanic	-0.034	-31.250	-0.017	-6.492	-0.017	-6.492	-0.054	-18.898	-0.034	-31.250	-0.015	-10.923	--	--
% White	-0.028	-28.430	-0.019	-7.350	-0.017	-6.046	-0.058	-21.146	--	--	--	--	0.012	21.867
% Black/African American	-0.027	-25.486	-0.041	-13.938	-0.020	-6.789	-0.060	-20.860	-0.031	-16.308	-0.027	-25.486	--	--
% 0-Vehicle Households	0.023	11.637	0.035	10.805	--	--	--	--	--	--	--	--	0.027	11.490
Median income (thousands)	0.013	28.597	0.013	28.597	--	--	--	--	0.027	39.217	-0.015	-13.128	0.013	28.597
Job Density	0.869	39.318	0.754	26.327	--	--	0.841	23.167	0.754	26.327	--	--	0.891	33.427
Land Use Mix	--	--	1.060	11.406	--	--	--	--	1.655	13.671	4.416	35.211	2.613	35.472
Ln(Parcel Area)	--	--	-0.080	-11.808	0.626	55.943	-0.204	-33.038	--	--	--	--	-0.125	-25.272
% Other Residential	--	--	0.010	8.911	-0.025	-8.743	-0.025	-15.441	0.025	29.119	0.025	29.119	--	--
% Vacant land Use	-0.009	-14.781	-0.013	-11.604	-0.023	-16.241	-0.010	-13.436	0.040	45.493	-0.050	-23.271	-0.010	-13.436

12.2.9 Other Land Uses

Table 62 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.860	-50.135
Population density	-0.030	-5.843
Median Income (in thousands)	0.004	6.868
Job Density	0.255	8.651
% Single Family Residential	0.008	9.978
% Others Land Use	-0.036	-29.670
% Vacant Land Use	-0.010	-13.250
Land Use Mix	1.232	14.263
Ln(Parcel Area in Acre)	-0.095	-15.610

Table 63 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.608	10.942
Population Density	0.021	5.361
% Hispanic	0.016	21.338
% Black American	-0.005	-8.124
% Other Race	-0.023	-6.110
% 0-Vehicle Households	-0.013	-5.574
Median Income (in thousands)	0.012	21.675
Job Density	-0.838	-34.622
% Single Family Residential	-0.005	-7.899
% Vacant Land Use	-0.011	-18.371
Land Use Mix	0.372	5.238
Ln(Parcel area in acre)	0.258	52.743

Table 64 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.055	-25.645
Population Density	-0.021	-5.366
Median Income (in thousands)	-0.002	-3.750
Job Density	-0.633	-21.376
% Single Family Residential	-0.003	-4.269
% Other Land uses	0.012	11.830
% Commercial Land use	-0.012	-7.356
% Vacant Land use	0.007	11.627
Ln(Parcel area in acre)	-0.035	-5.400

Table 65 MNL Model of New Land Use Type (Base: Vacant Residential)

Variable	Other Residential		Single-Family Residential		Agricultural		Public		Vacant Public		Low Share Category	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Intercept	-2.261	-32.553	-0.644	-12.369	1.202	15.654	-0.638	-8.785	-3.356	-46.750	-2.318	-32.826
Population Density	0.317	54.800	--	--	-0.471	-20.384	--	--	0.127	11.314	0.191	33.030
% Hispanic	-0.020	-21.451	--	--	0.007	7.029	0.008	6.840	--	--	--	--
% Black American	-0.012	-12.659	0.007	8.823	0.019	16.639	0.024	19.606	0.006	4.049	--	--
% Asian	0.033	9.727	0.020	5.017	--	--	--	--	0.031	5.012	--	--
% Other Race	0.035	7.210	0.028	5.235	--	--	0.024	3.561	--	--	0.035	6.493
% 0- Vehicle Households	--	--	--	--	--	--	-0.029	-6.741	0.012	2.671	0.023	10.173
Median Income (in thousands)	0.020	34.609	-0.003	-4.609	-0.010	-9.940	--	--	--	--	--	--
Job Density	-0.641	-18.791	-0.423	-11.861	-0.630	-12.751	-1.831	-32.310	0.430	8.203	0.538	16.067
% Single Family Residential	-0.003	-2.909	0.020	27.060	--	--	--	--	-0.014	-7.519	-0.016	-16.396
% Other Land Uses	0.008	7.420	--	--	0.017	11.942	-0.031	-13.594	0.025	13.610	--	--
% Vacant Land Use	-0.023	-21.223	-0.019	-17.833	-0.009	-10.658	-0.010	-8.532	0.040	36.932	-0.013	-11.761
Land Use Mix	1.843	19.223	--	--	-2.912	-24.154	0.530	4.009	--	--	2.093	19.036
Ln(Parcel area in acre)	--	--	-0.293	-45.211	0.329	40.301	-0.101	-11.559	--	--	-0.136	-20.785

12.2.10 Public Land Use

Table 66 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-1.944	-17.223
% Hispanic	-0.013	-11.298
% 1/1+ vehicle households	-0.016	-10.849
Median Income (in thousands)	-0.013	-10.946
Job Density	0.436	10.643
% Vacant Land Use	0.003	2.833
% Single-family Residential	0.005	5.883
% Public Land Use	-0.023	-24.911
% Other Land Use	-0.016	-6.449
Land Use Mix	1.014	9.109
Ln(Parcel Area in acre)	-0.156	-20.750
% High Flood Risk Zone	0.004	6.323

Table 67 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	2.305	21.171
Population Density	0.045	8.097
% Black American	0.003	3.861
% Asian	0.014	2.751
% 1/1+ vehicle households	-0.015	-10.581
Median Income (in thousands)	-0.014	-12.285
Job Density	-0.921	-22.260
% Vacant Land Use	0.023	17.198
% Other Residential	-0.034	-12.978
% Single-Family Residential	0.005	6.125
% Public Land Use	0.004	4.275
% Other Land Use	-0.006	-2.970
Land Use Mix	-0.481	-4.464
Ln(Parcel Area in acre)	0.306	39.841

Table 68 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.656	-5.061
% Hispanic	-0.012	-10.457
% Black American	-0.006	-7.200
Median Income (in thousands)	-0.010	-7.093
% 1/1+ vehicle households	-0.006	-3.802
% Vacant Land Use	-0.005	-3.498
% Public Land Use	-0.002	-2.054

% Single-Family Residential	-0.005	-5.296

Table 69 MNL Model of New Land Use Type (Base: Vacant Public)

Variable	Single Family Residential		Vacant Residential		Others		Other Residential		Commercial		Recreational		Vacant Commercial		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	-2.549	-19.024	-0.649	-8.241	0.532	1.437	0.425	1.060	-0.373	-0.971	-3.596	-18.804	-4.200	-18.48	0.469	2.770
Population Density	--	--	-0.134	-14.918	-0.134	-14.918	--	--	--	--	0.068	7.591	--	--	-0.033	-4.625
% Hispanic	0.021	15.514	0.027	18.464	-0.016	-4.360	-0.016	-4.360	-0.016	-4.360	--	--	--	--	--	--
% White	--	--	--	--	-0.028	-7.675	-0.035	-9.151	-0.028	-7.675	--	--	--	--	-0.018	-12.578
% Black American	0.010	10.563	0.012	11.963	-0.019	-4.942	-0.042	-9.521	-0.034	-8.551	--	--	--	--	-0.014	-8.850
% Asian	--	--	0.023	3.186	--	--	-0.058	-5.431	-0.059	-5.032	--	--	--	--	-0.029	-4.095
% 1-Vehicle Households	--	--	--	--	--	--	-0.023	-3.395	--	--	-0.051	-6.526	--	--	0.014	4.106
% 3/3+-Vehicle Households	-0.042	-12.374	-0.017	-5.539	-0.024	-6.461	-0.019	-4.324	-0.086	-16.315	-0.062	-11.679	-0.044	-7.598	-0.031	-9.250
Median income (in thousands)	0.020	14.586	--	--	0.021	12.620	0.025	13.740	0.020	14.586	0.024	11.490	0.012	5.333	0.010	5.955
Job Density	-0.191	-3.432	-0.989	-13.780	-0.940	-11.122	--	--	0.684	8.298	--	--	0.519	6.257	0.614	10.794
Land Use Mix	0.762	5.203	--	--	2.098	15.015	2.098	15.015	3.256	17.309	3.256	17.309	3.537	12.54	1.396	9.849
% Vacant Land Use	-0.012	-6.615	-0.005	-3.633	-0.031	-15.667	-0.035	-12.361	-0.051	-12.701	-0.031	-15.667	-0.009	-3.068	-0.033	-16.634
% Public Land Use	-0.005	-3.262	-0.012	-12.909	-0.016	-14.069	-0.016	-14.069	-0.016	-14.069	-0.012	-12.909	-0.007	-2.939	-0.012	-12.909
% Single-Family Residential	0.014	12.392	--	--	--	--	-0.020	-11.769	-0.009	-5.091	0.009	4.707	--	--	-0.016	-12.591
Ln(Parcel Area in acre)	-0.451	-37.168	-0.315	-27.506	-0.103	-8.888	-0.382	-24.812	-0.316	-17.489	0.127	7.997	-0.181	-9.769	-0.140	-13.892

12.2.11 Recreational Land Use

Table 70 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.062	-46.655
Population Density	0.021	10.317
% Hispanic	-0.012	-18.727
% Black American	-0.015	-15.045
% Asian and other races	-0.008	-3.389
% 2/2+ vehicle households	0.004	6.263
% Vacant Land Use	-0.034	-29.781
Ln(Parcel Area in acre)	-0.072	-19.531
% High Flood Risk Zone	0.009	25.904

Table 71 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.207	2.167
Population Density	0.101	11.138
% Hispanic	0.005	3.804
% Black American	0.013	5.872
% Asian and other races	-0.028	-4.846
% 2-Vehicle Households	0.013	4.518
% 3/3+ vehicle households	-0.035	-9.942
Median Income (in thousands)	0.017	10.903
% Public Land Use	-0.004	-2.739
% Single-Family Residential	-0.005	-3.150
% Vacant Land Use	-0.031	-15.789
Ln(Parcel Area in acre)	0.391	37.657

Table 72 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.219	-7.155
Population (in thousands)	-0.096	-6.367
% Hispanic, Asian and other races	0.010	6.383
% Black American	-0.019	-5.110
% 0,1-Vehicle Households	0.006	2.818
Median Income (in thousands)	-0.003	-2.170
% Agricultural Land Use	0.011	9.585
% Vacant Land Use	-0.007	-3.302
% Public Land Use	-0.012	-7.234
Ln(Parcel Area in acre)	0.024	2.124

Table 73 MNL Model of New Land Use Type (Base: Public)

Variable	Single-Family Residential		Vacant Residential Area		Other Residential		Others		Low Share Categories	
	Estimate	**t stat**	**Estimate**	**t stat**	**Estimate**	**t stat**	**Estimate**	**t stat**	**Estimate**	**t stat**
Constant	-3.300	-24.057	-2.534	-13.202	-1.976	-17.853	-1.772	-12.075	-1.419	-11.066
Population Density	0.305	13.291	--	--	0.659	46.559	0.299	12.639	0.420	21.607
% Black American	--	--	--	--	--	--	--	--	0.014	6.413
% Hispanic	0.033	12.774	0.042	15.531	0.020	9.520	0.030	11.287	0.009	3.328
% Asian and other races	0.055	5.503	0.071	5.969	0.034	4.555	0.034	3.103	0.035	3.906
% 2- vehicle households	--	--	-0.023	-3.841	0.006	2.143	-0.041	-8.681	-0.017	-4.125
% 3/3+ vehicle households	0.034	5.723	0.037	5.317	0.013	3.185	--	--	0.057	11.815
Median Income (in thousands)	-0.013	-5.921	-0.010	-3.178	--	--	0.009	4.274	-0.012	-5.686
% Single-Family Residential	0.030	12.856	0.023	8.524	--	--	0.012	4.658	0.004	2.125
% Public Land Use	0.006	2.709	-0.014	-4.189	-0.024	-12.892	--	--	-0.015	-7.237
% Vacant Land Use	0.022	7.221	0.035	12.400	--	--	0.008	2.267	--	--

12.2.12 Single-Family Residential Land Use

Table 74 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-4.333	-52.797
% Hispanic	-0.015	-8.528
% 0- Vehicle Households	0.021	4.852
Job Density	0.205	3.634
% Single-Family Residential	-0.020	-14.962
% Multi Family Residential	0.012	2.837
Ln(Parcel Area in acre)	-0.435	-15.306
% Flood Risk Zone A	0.007	2.817

Table 75 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	-0.647	-15.894
% Hispanic	0.013	21.618
% Asian	-0.056	-15.692
% 0- Vehicle Households	0.029	20.975
Job Density	-0.515	-21.073
% Single-Family Residential	0.010	20.954
% Mixed Use	0.162	17.130
% Vacant Land Use	-0.004	-6.619
Land Use Mix	-1.096	-16.826
Ln(Parcel Area in acre)	0.588	75.955

Table 76 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.498	-97.562
Population Density	-0.019	-10.052
% Black American	-0.005	-16.280
% Asian	-0.009	-6.935
Job Density	-0.393	-29.404
% Single Family Residential	-0.004	-13.956
% Mixed Use Land Use	0.062	9.861
% Commercial Land Use	-0.012	-20.465
% Vacant Land Use	-0.005	-14.264
Ln(Parcel Area in acre)	-0.017	-2.850

Table 77 MNL Model of New Land Use Type (Base: Other Residential)

Variables	Vacant Residential		Others		Multi-Family 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
Constant	0.784	18.591	-1.106	-17.035	-1.380	-22.028	-2.208	-25.979	-1.065	-9.971	0.793	12.623	-1.522	-26.308
Population Density	-0.061	-18.932	-0.091	-18.970	--	--	--	--	--	--	-0.379	-20.561	-0.075	-20.038
% Black American	0.009	21.119	--	--	--	--	--	--	0.004	4.323	--	--	0.008	15.461
% Asian	-0.085	-30.646	--	--	-0.066	-15.692	--	--	--	--	-0.054	-7.886	-0.030	-11.219
% 0- Vehicle Households	0.085	48.267	--	--	0.103	46.386	--	--	0.053	14.478	--	--	0.085	43.428
Median Income (in thousands)	--	--	0.005	9.388	-0.017	-18.545	--	--	-0.017	-14.696	--	--	--	--
Job Density	-0.604	-30.580	-0.826	-32.742	--	--	-1.656	-43.601	-1.308	-31.266	--	--	--	--
% Single Family Residential	0.023	44.469	0.015	20.879	0.034	53.527	0.012	11.931	0.028	31.147	--	--	0.023	36.839
% Vacant Land Use	0.026	50.927	--	--	--	--	-0.046	-21.718	-0.024	-12.748	--	--	--	--
Land Use Mix	-1.934	-31.173	0.485	5.824	--	--	2.671	20.756	1.122	8.856	-2.063	-16.307	0.474	5.777
Ln(Parcel Area in acre)	0.340	47.126	--	--	0.369	34.877	--	--	0.334	24.743	0.978	68.899	0.224	26.232

12.2.13 Vacant Commercial Land Use

Table 78 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.346	-12.609
Population Density	-0.017	-4.690
% Hispanic	-0.007	-8.310
% 1- Vehicle Households	-0.014	-6.313
% 2- Vehicle Households	-0.017	-7.898
% 3/3+ Vehicle Households	-0.032	-11.230
Median Income (in thousands)	0.019	20.093
Job Density	0.588	21.490
% Vacant Land Use	-0.007	-8.414
% Commercial Land Use	0.006	4.683
% Public Land Use	-0.005	-4.477
Land Use Mix	0.596	6.042
Ln(Parcel Area in acre)	-0.059	-7.521

Table 79 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.390	6.303
Household Density	0.244	17.188
% Hispanic	0.017	19.337
% 0- Vehicle Households	-0.025	-12.523
Median Income (in thousands)	-0.003	-4.082
Job Density	-0.556	-18.175
% Vacant Land Use	0.006	6.825
% Other Land Uses	0.013	7.520
% Public Land Use	0.011	10.530
Ln(Parcel Area in acre)	0.291	36.246

Table 80 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-2.110	-40.355
Population Density	-0.021	-4.138
% Black American	-0.006	-7.290
% 0- Vehicle Households	-0.007	-3.150
Median Income (in thousands)	0.006	9.169
Job Density	-0.093	-2.739
% Vacant Land Use	0.012	14.197
% Commercial Land Use	0.005	3.619
% Other Residential Land Uses	0.013	10.036
Ln(Parcel Area in acre)	-0.050	-4.736

Table 81 MNL Model of New Land Use Type (Base: Commercial)

Variables	Office		Other Residential		Vacant Residential		Single-Family Residential		Industrial		Others		Public		Multi-Family Residential		Institutional		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	-1.77	-13.73	-3.19	-27.69	0.28	2.00	0.13	0.90	-0.65	-6.43	-1.43	-19.90	-1.08	-17.28	-2.99	-29.98	-1.71	-22.36	-0.49	-3.99
Household Density	0.08	4.83	-0.24	-7.90	0.11	5.85	--	--	-0.23	-8.38	--	--	--	--	0.16	9.97	--	--	--	--
% Hispanic	0.00	-3.58	-0.01	-5.25	-0.01	-7.13	-0.02	-12.16	--	--	--	--	--	--	--	--	-0.01	-3.34	--	--
% 0- Vehicle Households	--	--	-0.04	-7.61	-0.02	-4.26	--	--	--	--	-0.04	-8.21	--	--	0.03	8.67	--	--	--	--
Median Income (in thousands)	0.01	8.37	0.02	16.63	-0.01	-3.93	-0.02	-9.75	-0.01	-7.63	--	--	--	--	--	--	--	--	-0.01	-5.34
Job Density	-0.23	-4.81	--	--	-0.86	-14.81	0.18	3.35	0.30	5.21	0.25	3.92	-0.84	-11.17	0.69	9.53	0.24	3.47	-0.31	-7.10
% Vacant Land Use	--	--	0.04	30.40	0.03	25.86	--	--	0.01	5.87	--	--	--	--	0.01	3.48	--	--	0.02	13.54
% Commercial Land Use	-0.01	-4.78	0.01	5.88	-0.03	-9.73	-0.03	-8.17	-0.02	-6.90	-0.02	-4.79	-0.02	-6.14	-0.02	-4.41	-0.03	-7.68	-0.03	-12.10
% Other Residential Land Uses	--	--	0.06	27.25	--	--	-0.02	-5.30	-0.02	-3.88	-0.02	-3.64	-0.01	-2.69	--	--	-0.02	-4.16	-0.02	-7.74
Land Use Mix	0.88	5.22	0.00	NA	-1.45	-8.76	-0.98	-5.01	--	--	--	--	--	--	--	--	--	--	0.67	4.17
Ln(Parcel Area in acre)	-0.11	-9.69	-0.10	-7.66	-0.10	-7.97	-0.23	-16.12	--	--	0.06	3.31	0.07	3.59	0.22	10.65	--	--	0.12	10.21

12.2.14 Vacant Industrial Land Use

Table 82 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-3.018	-55.205
Household Density	-0.095	-6.210
% Hispanic	-0.015	-23.131
% 2/2+ Vehicle Households	-0.005	-3.785
Median Income (in thousands)	0.007	6.110
Job Density	0.724	26.203
% Commercial Land Use	0.008	4.387
% Other Land Uses	0.005	2.989
Ln(Parcel Area in acre)	-0.177	-20.204

Table 83 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.281	1.203
Household Density	0.448	10.290
% Hispanic	0.029	12.097
% Black American	0.008	4.721
% Asian	-0.024	-2.846
% 0- Vehicle Households	-0.021	-3.960
Median Income (in thousands)	0.007	2.724
Job Density	-0.835	-10.063
% Commercial Land Use	0.023	4.183
% Public Land Use	0.017	7.135
% Other Land Uses	0.027	5.704
Land Use Mix	-1.153	-3.852
Ln(Parcel Area in acre)	0.496	20.942

Table 84 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-1.292	-6.215
Household Density	0.106	2.632
% Hispanic	0.008	3.015
Median Income (in thousands)	-0.009	-2.993
% 0- Vehicle Households	-0.032	-5.012
Job Density	-0.297	-3.148

Table 85 MNL Model of New Land Use Type (Base: Industrial)

Variables	Commercial		Vacant Commercial		Others		Single Family Residential		Public		Vacant 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	Est.	t stat
Constant	-1.632	-6.899	-0.233	-1.051	-1.437	-4.496	-1.592	-4.467	-1.211	-4.135	-1.988	-9.783	-1.182	-3.528	-0.455	-1.704
Population Density	0.056	3.712	0.068	4.131	--	--	-0.114	-2.921	--	--	--	--	-0.204	-2.222	0.044	2.702
% Hispanic	0.010	3.980	--	--	0.006	1.843	-0.020	-3.162	--	--	--	--	--	--	--	--
% Black American	0.004	1.748	--	--	0.006	2.248	0.009	3.697	0.009	3.041	0.011	3.883	--	--	0.013	7.014
% 2/2+ Vehicle Households	-0.017	-3.304	-0.021	-3.960	0.011	2.290	-0.020	-3.844	--	--	--	--	--	--	--	--
Median Income (in thousands)	0.010	2.173	0.012	2.553	--	--	--	--	-0.011	-2.054	--	--	--	--	0.011	3.531
Job Density	0.358	2.898	-0.532	-4.215	--	--	0.416	2.248	-0.548	-3.079	0.431	2.476	-0.418	-2.077	-0.239	-2.085
% Commercial Land Use	--	--	0.016	2.513	-0.019	-2.049	-0.026	-2.282	--	--	--	--	-0.060	-2.969	--	--
% Public Land Use	--	--	--	--	-0.028	-5.313	--	--	--	--	-0.017	-2.884	-0.010	-1.918	-0.018	-5.377
% Single-Family Residential	--	--	--	--	-0.031	-5.729	0.011	1.886	--	--	-0.019	-3.126	-0.038	-3.307	-0.017	-4.947
% Industrial Land Use	-0.006	-1.761	-0.037	-7.734	-0.017	-3.965	--	--	-0.019	-3.256	-0.030	-5.201	-0.046	-4.950	-0.032	-8.374
Land Use Mix	--	--	--	--	--	--	--	--	--	--	--	--	1.271	1.922	-0.709	-2.170
Ln(Parcel Area in acre)	--	--	0.117	3.776	-0.086	-2.405	-0.314	-7.329	0.110	2.602	--	--	0.365	7.596	-0.082	-2.980

12.2.15 Vacant Institutional Land Use

Table 86 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.323	-41.842
Population Density	-0.046	-8.662
% Hispanic	0.006	7.454
% Black American	0.003	4.906
% 0- Vehicle Households	0.021	11.291
Median Income (in thousands)	0.004	4.69
Job Density	0.133	3.391
% Vacant Land Use	0.006	9.289
% High Flood Risk Zone	-0.003	-4.941

Table 87 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	1.970	7.296
Household Density	0.311	5.659
% Hispanic	0.025	7.218
% 0- Vehicle Households	-0.038	-6.986
Median Income (in thousands)	-0.013	-4.194
Job Density	-3.213	-26.141
% Vacant Land Use	0.015	6.579
% Other Land Uses	0.059	10.134
Land Use Mix	1.908	6.372
Ln(Parcel Area in acre)	0.340	12.404

Table 88 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.794	-4.105
% 0- Vehicle Households	-0.018	-3.661
Median Income (in thousands)	-0.011	-3.970
Job Density	-0.691	-6.126
% Vacant Land Use	-0.006	-3.347
Ln(Parcel Area in acre)	0.164	5.186

Table 89 MNL Model of New Land Use Type (Base: Vacant Public)

Variable	Other residential		Institutional		Vacant residential		Single family residential		Other categories	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-0.878	-4.473	-1.749	-6.416	-2.724	-10.593	-3.304	-12.943	-0.868	-5.404
Population Density	0.143	7.212	0.233	12.214	0.141	6.075	0.215	10.217	0.116	5.786
% Hispanic	0.006	2.416	-0.009	-3.011	0.020	5.945	0.032	9.395	-0.019	-5.967
% Black American	-0.017	-6.813	-0.008	-3.872	0.009	3.661	0.006	2.272	-0.014	-6.986
% 0- Vehicle Households	-0.099	-13.437	-0.029	-5.047	-0.065	-8.649	-0.040	-5.450	-0.017	-3.094
Median Income (in thousands)	0.010	4.340	-0.008	-2.692	--	--	--	--	-0.016	-5.957
Job Density	--	--	3.090	17.117	4.303	22.082	4.402	22.149	3.905	21.673
% Vacant Land Use	--	--	-0.013	-5.090	0.021	8.590	-0.017	-4.783	--	--
Land Use Mix	1.114	4.393	1.104	3.568	-2.349	-6.586	-1.692	-4.529	--	--
Ln(Parcel Area in acre)	-0.156	-10.078	-0.095	-4.580	-0.402	-14.168	-0.572	-15.502	--	--

12.2.16 Vacant Public Land Use

Table 90 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-2.546	-41.452
Population (in thousands)	0.033	5.918
% White	0.004	6.612
% 0- Vehicle Households	0.017	8.770
% Agricultural Land Use	-0.004	-4.685
% Vacant Land Use	-0.022	-25.735
Ln(Parcel Area in acre)	-0.257	-30.131
% High Flood Risk Zone	-0.010	-15.315

Table 91 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.073	0.987
Population Density	0.174	23.120
% White	-0.008	-9.896
% 0- Vehicle Households	-0.022	-9.244
% Public Land Use	0.019	11.588
% Agricultural Land Use	0.006	5.881
% Single-Family Residential	-0.011	-9.987
Ln(Parcel Area in acre)	0.334	35.511

Table 92 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.216	-2.802
Population Density	-0.125	-11.652
% Hispanic	0.012	9.398
% Asian and Other Races	-0.018	-5.744
% 2/2+ Vehicle Households	-0.020	-17.014
% Public Land Use	-0.024	-11.536
% Commercial Land Use	-0.018	-6.689
Ln(Parcel Area in acre)	0.098	10.787

Table 93 MNL Model of New Land Use Type (Base: Singe-Family Residential)

Variable	Vacant residential		Public		Other residential		Recreational		Commercial		Vacant commercial		Others		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	0.705	7.545	-0.079	-0.749	-2.712	-23.376	-1.234	-9.081	-2.424	-17.953	-1.542	-9.980	-0.335	-3.447	0.092	1.141
Population (in thousands)	-0.216	-11.424	-0.062	-4.893	0.077	9.209	-0.108	-4.936	--	--	--	--	--	--	-0.021	-2.186
% White	--	--	--	--	--	--	0.010	6.459	0.005	3.358			-0.004	-3.874		
% 3/3+ Vehicle Households	0.031	7.868	--	--	--	--	--	--	-0.031	-4.861	-0.048	-7.307	-0.020	-5.657	-0.038	-10.249
Median Income (in thousands)	-0.029	-17.076	-0.015	-10.685	0.015	9.860	--	--	--	--	--	--	0.012	9.136	--	--
% Agricultural Land Use	0.023	11.705	0.041	22.299	0.032	15.028	--	--	0.021	6.355	0.020	5.529	0.019	9.526	0.037	20.582
% Commercial Land Use	--	--	0.054	12.600	0.050	10.349	0.044	8.019	0.089	20.683	0.080	16.173	0.038	9.162	0.059	15.923
% Public Land Use	0.017	6.348	0.046	19.076	--	--	--	--	0.024	6.170	0.024	5.829	0.019	7.428	0.017	6.450
% Vacant Land Use	0.025	19.584	0.018	12.215	--	--	--	--	--	--	0.016	6.461	0.014	11.282	--	--
Ln(Parcel Area in acre)	0.220	13.329	0.549	33.425	0.043	2.125	0.813	38.822	--	--	0.360	14.068	0.504	32.141	0.376	23.094

12.2.17 Vacant Residential Land Use

Table 94 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-3.362	-51.084
Population (in thousands)	0.064	16.760
% White	-0.002	-3.079
% 3/3+ Vehicle Households	-0.029	-14.169
Median Income (in thousands)	0.022	27.902
Job Density	0.911	27.508
% Vacant Land Use	-0.027	-36.253
Ln(Parcel Area in acre)	-0.267	-22.219

Table 95 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.223	5.344
Population (in thousands)	0.122	37.871
% Black American	-0.014	-35.398
% Hispanic, Asian and other races	0.016	31.355
% 1/1+ Vehicle Households	0.010	15.574
% Vacant Land Use	-0.007	-15.927
% Commercial Land Use	0.019	16.974
% Recreational Land Use	-0.008	-9.742
Ln(Parcel Area in acre)	0.106	17.293

Table 96 MNL based Fraction Split Model (Base: Previous Land Use)

Variable	Estimate	t stat
Constant	-0.094	-8.224
Population Density	-0.028	-5.711
% White	-0.003	-4.538
% 3/3+ Vehicle Households	0.005	3.349
% Agricultural Land Use	0.003	5.483
% Single-Family Residential	-0.008	-12.686
% Vacant Land Use	-0.005	-8.545
Ln(Parcel Area in acre)	-0.016	-2.281

Table 97 MNL Model of New Land Use Type (Base: Singe-Family Residential)

Variable	Other residential		Agricultural		Public		Others		Low Share Categories	
	Est.	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**	**Est.**	**t stat**
Constant	-1.143	-71.108	-1.716	-24.666	-1.946	-26.774	-2.262	-69.630	-1.982	-44.838
Population Density	0.098	28.978	-0.457	-10.824	-0.082	-4.703	-0.048	-5.611	0.124	31.736
% Black American	-0.010	-16.066	--	--	0.006	4.052	--	--	0.009	16.926
% Asian	-0.019	-7.064	-0.174	-13.837	--	--	-0.074	-12.159	-0.088	-17.553
% 3/3+ Vehicle Households	--	--	0.021	7.239	-0.051	-14.040	--	--	-0.028	-14.711
% Single-Family Residential	--	--	-0.020	-7.922	-0.023	-10.833	--	--	--	--
% Vacant Land Use	--	--	-0.019	-12.934	--	--	0.008	9.305	0.010	14.555
Ln(Parcel Area in acre)	0.372	49.221	0.885	61.774	0.350	18.384	0.425	33.910	0.281	25.428

12.2.18 Water Land Use

Table 98 Binary Logit Model of Land Use Change (Base: No Change)

Variable	Estimate	t stat
Constant	-4.213	-21.38
% 1- Vehicle Households	0.0232	10.296
% 2- Vehicle Households	0.018	6.452
Median Income (in thousands)	0.004	5.534
% Vacant Land Use	-0.009	-6.897
% Public Land Use	0.004	3.137
% Water Land Use	0.011	6.689
Ln(Parcel Area in acre)	-0.181	-23.694
% High Flood Risk Zone	-0.007	-11.087

Table 99 Binary Logit Model of Full/Partial Change (Base: Partial Change)

Variable	Estimate	t stat
Constant	0.501	2.538
Population Density	0.141	11.048
% Hispanic	0.008	2.665
% 3/3+ Vehicle Households	-0.040	-7.607
Median Income (in thousands)	0.015	9.145
Job Density	-0.510	-6.45
% Other Land Uses	0.010	2.616
% Public Land Use	0.005	1.985
% Water Land Use	0.030	6.93
Land Use Mix	-0.627	-2.332
Ln(Parcel Area in acre)	0.470	26.292

Table 100 MNL based Fraction Split Model (Base: Previous Land Use)

Parameters	Estimates	t Statistic
Constant	-1.156	-7.99
Population Density	-0.082	-5.32
% Hispanic	-0.008	-2.586
% 0- Vehicle Households	-0.029	-2.443
Median Income (in thousands)	-0.009	-4.738
Job Density	0.197	2.574
% Other Land Uses	0.010	3.431
% Water Land Use	0.019	4.444
Ln(Parcel Area in acre)	-0.060	-2.907

Table 101 MNL Model of New Land Use Type (Base: Other Residential)

Variable	Others		Single family residential		Vacant public		Public		Vacant residential		Other categories	
	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat	Est.	t stat
Constant	-0.278	-1.237	0.545	1.945	0.016	0.076	1.959	6.525	1.094	4.200	0.643	3.140
Household density	-0.666	-13.590	-0.534	-10.347	-0.419	-6.579	-1.536	-13.188	-1.365	-13.883	-0.765	-14.760
% Hispanic	0.016	5.400	--	--	0.013	3.422	--	--	--	--	--	--
% Black American	0.014	4.795	--	--	--	--	-0.041	-5.040	--	--	--	--
% 0- Vehicle Households	0.046	3.758	--	--	--	--	--	--	--	--	0.062	5.021
Median Income (in thousands)	-0.012	-5.684	-0.015	-7.213	-0.007	-3.002	-0.025	-8.754	-0.031	-9.696	-0.012	-5.516
Job Density	--	--	--	--	-1.376	-8.324	-1.144	-6.583	--	--	--	--
% Vacant Land Use	0.011	2.567	0.031	7.734	0.032	8.769	--	--	0.039	8.998	--	--
% Other Land Uses	0.013	3.253	-0.013	-2.256	-0.053	-7.295	--	--	-0.022	-2.835	-0.011	-2.272
% Water Land Use	-0.020	-3.783	-0.034	-5.340	--	--	-0.033	-3.669	-0.016	-2.023	-0.050	-7.488
Land Use Mix	--	--	-0.814	-2.298	--	--	1.122	2.552	--	--	--	--
Ln(Parcel Area in acre)	-0.316	-14.282	-0.512	-22.337	0.134	4.350	-0.137	-4.451	-0.488	-17.790	-0.317	-13.790