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Review of Landuse Transportation Interaction Model in Smart Urban Growth Management

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Abstract

Land use and transportation systems play a vital role in shaping the dynamics of urban areas, with profound implications for sustainability, mobility, and quality of life. Researchers and policymakers have developed various Land Use Transportation Interaction (LUTI) models to understand the intricate relationship between land use and transportation. These models aim to capture the complex interactions between land-use patterns and transportation systems, enabling more informed planning and decision-making processes. This study provides a comprehensive review of the applicability of LUTI models, highlighting their strengths, limitations, and potential for addressing contemporary urban challenges. This review encompasses many LUTI models, including microsimulation, spatial econometric, and integrated land-use transport models. It examined the underlying theoretical foundations, data requirements, calibration techniques, and computational aspects. This review identifies key factors influencing the applicability of LUTI models, such as data availability, computational capabilities, and the specific urban context in which they are applied. It explores the challenges faced in integrating land-use and transportation data, incorporating temporal dynamics, and capturing the impacts of policy interventions.

Keywords: Landuse, Transportation, Landuse Transportation, Landuse Transportation Interaction Model, LUTI model

Introduction

Sustainability is a compelling topic in global cities, particularly in the context of various development concepts. Urban sustainability is of particular concern in urban development. It is widely acknowledged that land use arrangement significantly influences the sustainability of cities (Tutuko et al., 2022). As the population expanded, the need for land increased, leading to the utilisation of land resources known as "land use." In India, the importance of land-use planning has increased owing to the scarcity of land (S. Sharma et al., 2023). The origin of Land Use Transportation Interaction (LUTI) models can be traced back to the mid-20th century, when urban planning and transportation studies began recognising the interdependent relationship between land use patterns and transportation systems (Lopane et al., 2023). The understanding that land use and transportation decisions influence each other and jointly shape urban development led to the development of integrated modelling approaches and the promotion of transition-oriented development for sustainable urban growth (Shahriari et al., 2023;

Sharma et al., 2024; Sharma & Dehalwar, 2025). The initial conceptual foundations of the LUTI models can be attributed to the work of urban economists and transportation planners. Scholars such as William Alonso, David Badoe, and Eric Miller have made significant contributions to the theoretical understanding of land use and transportation interactions (Badoe & Miller, 2000). Alonso's pioneering work on the bid-rent theory in the 1960s provided insights into the relationship between land value, accessibility, and transportation infrastructure (Gao et al., 2020). As urban areas expand and encounter growing mobility challenges, the need for quantitative models to capture the complex interplay between land use and transportation becomes increasingly apparent (Le et al., 2023). With the advent of computers and advancements in data availability, researchers have started developing formal modelling frameworks to simulate and analyse the interactions between land use and transportation systems (Zhong et al., 2022).

LUTI models provide a comprehensive understanding of how changes in one domain affect the other (Lopes et al., 2019). LUTI models were designed to capture both the spatial and temporal dimensions of land-use and transportation interactions. They simulated the movement of people and goods across urban areas, taking into account travel demand, mode choice, route selection, and travel times. These models also account for the feedback loops between land use and transportation, wherein changes in transportation infrastructure and accessibility influence land use decisions, and vice versa. (Ahasan & Güneralp, 2022). Advances in computing technology, data availability, and analytical techniques have facilitated the development of LUTI models. To calibrate and validate their outputs, these models incorporate various data sources, including land-use surveys, transportation network data, demographic data, and travel behavior surveys. Additionally, spatial analysis tools, econometric modeling techniques, and simulation algorithms have been employed to capture the complex dynamics of land use and transportation interactions (Kii et al., 2019).

The application of LUTI models has extended to various urban planning and policy domains. They evaluated the impacts of transportation infrastructure investments, land-use policy changes, and transit-oriented development strategies. LUTI models can assess the effects of alternative scenarios on travel patterns, congestion levels, energy consumption, air quality, and social equity, thus enabling policymakers to make informed decisions (Amalan et al., 2023). LUTI models have evolved in recent years to incorporate emerging technologies and concepts such as big data analytics, machine learning, and shared mobility services. These advancements enhance the accuracy and predictive capabilities of models, enabling a more robust understanding of the complex dynamics between land use and transportation. (Kii et al., 2019). This study aims to provide a comprehensive review of the applicability, strengths, limitations, and future directions of LUTI models. It explores the theoretical foundations, data requirements, modelling techniques, and practical implications of LUTI models for urban planning and policymaking. By understanding the complexities of land-use and transportation interactions, policymakers and planners can develop more sustainable, efficient, and livable urban environments.

Methodology

We conducted a systematic literature review with a rigorous and comprehensive approach to identify, evaluate, and synthesise existing research on specific land transportation interaction models for smart urban growth.

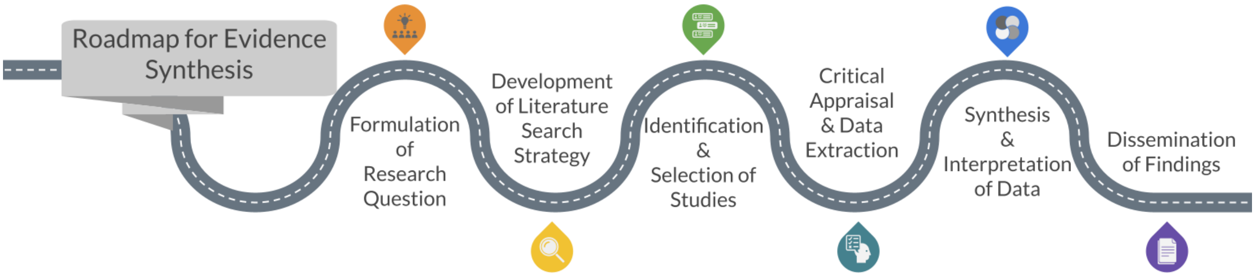

Fig. 2 Roadmap to Evidence synthesis used in this study (Cook & West, 2012).

We searched multiple databases, with a primary focus on Scopus, ScienceDirect, and Google Scholar, selecting relevant studies based on predefined criteria and critically appraising their quality. By analysing and summarising the findings, a systematic literature review provides an evidence-based overview of the current state of knowledge in this field.

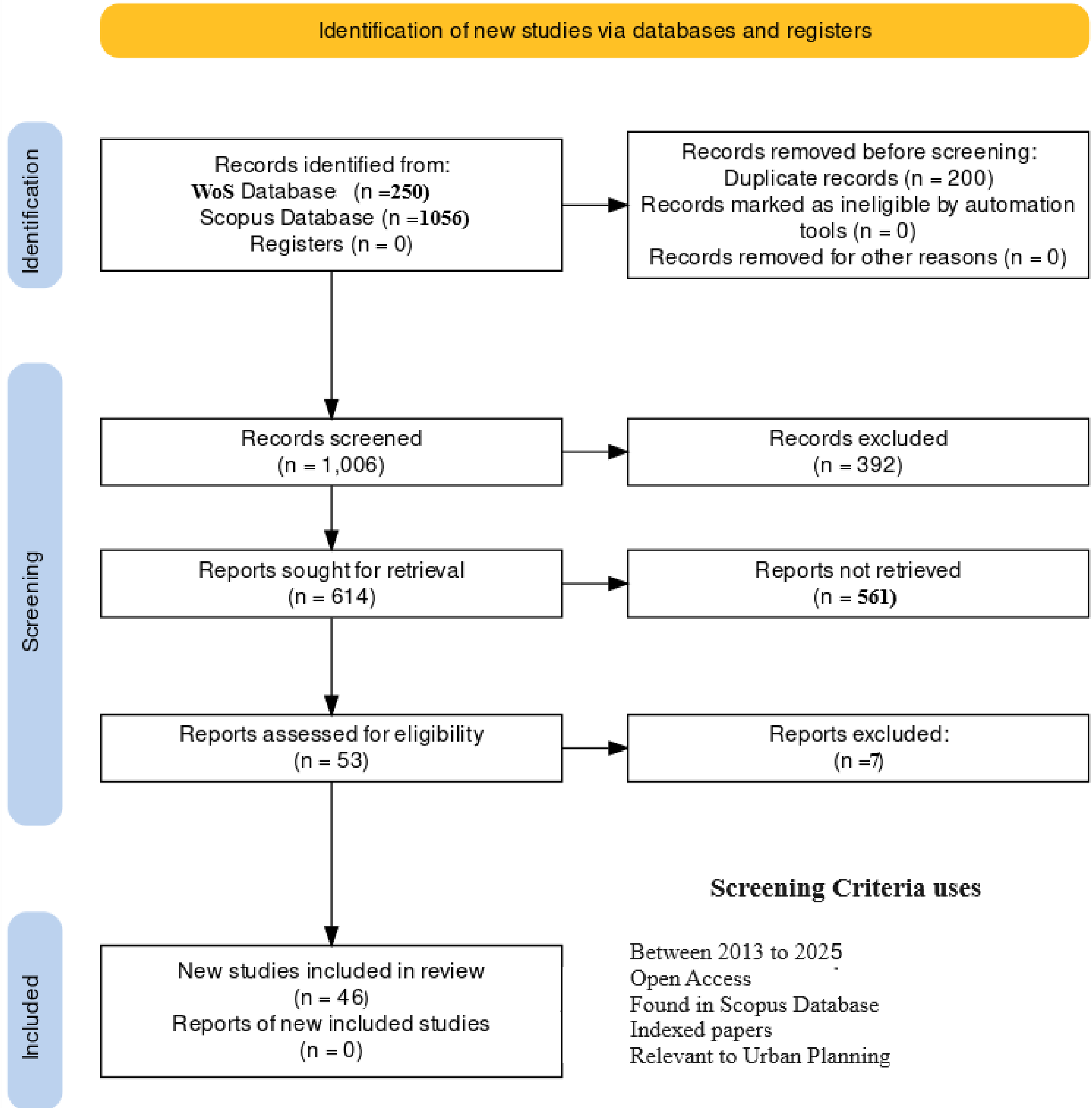

Fig. 1. Systematic Literature Review from Scopus Database (Page et al., 2021)

A total of 1,006 search terms related to the " land-use transportation model were used to initiate the search. The search results were limited to studies published between 2013 and 2025, with 614 studies, focusing on recent research. Of the initial search results, 137 research papers were deemed relevant based on the availability of open-access content. Among the appropriate papers, 71 were identified as related to the domain of urban planning. Abstract reading narrowed the selection of 53 relevant papers based on their abstracts. Finally, a detailed study was conducted on 46 papers deemed highly relevant based on their content and context.

These screening criteria helped refine the initial search results and ensure that the selected studies were recent, research-focused, accessible, and directly relevant to the topic of "Landuse Transportation Model."

Findings and Discussion

Analysis of the Available Literature

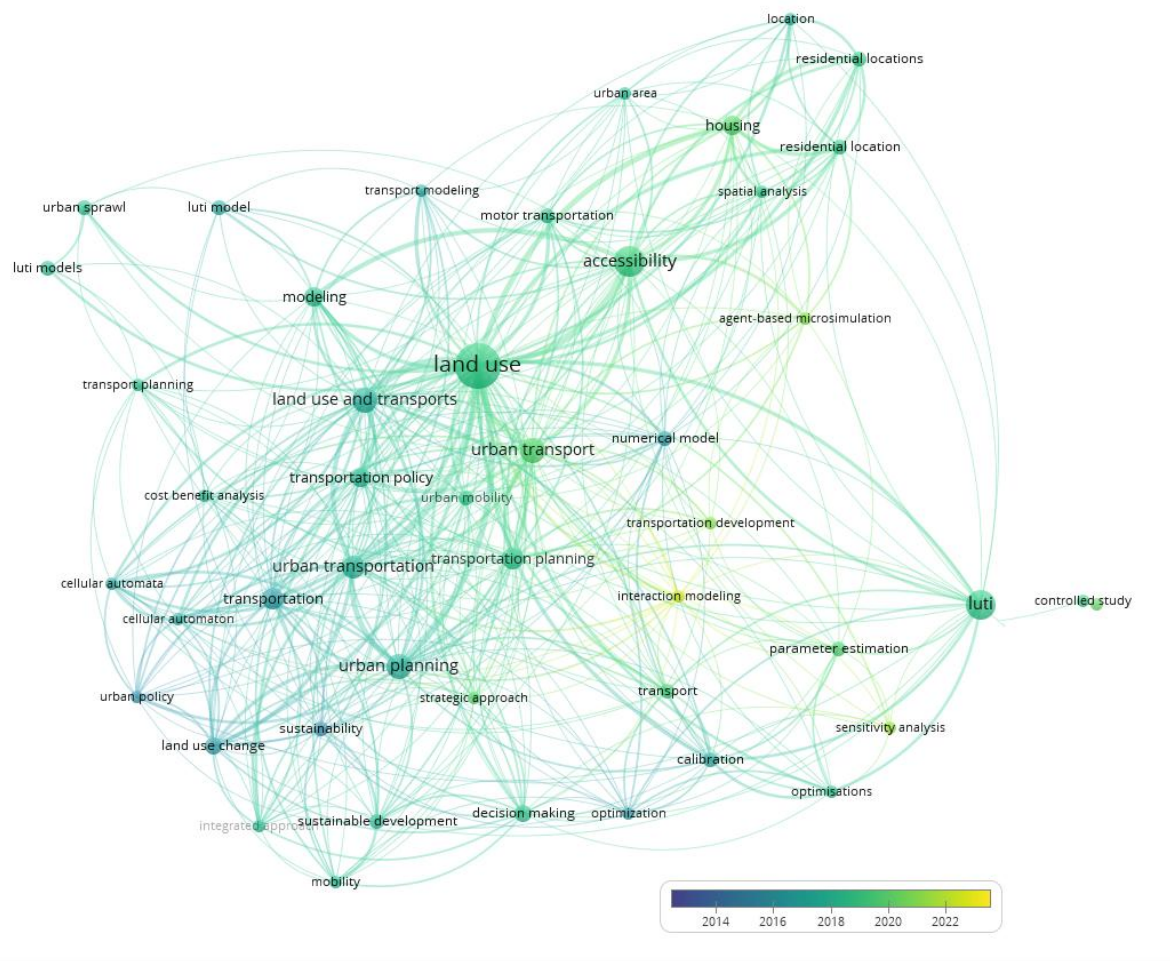

Fig. 1. Keyword analysis to assess the impact of the LUTI model.

The evolving landscape of Land Use and Transportation Integration (LUTI) models has been evident in the documented research output over the past decade, focusing on emerging uses and applications. The analysis revealed a notable increase in scholarly contributions over the years, signifying growing interest in harnessing LUTI models for diverse purposes. In 2013, there were four documents and there has been a consistent upward trend since. By 2018, the number of documents doubled, and the momentum continued with notable peaks in 2021 and 2025, with 10 and eight documents, respectively. This surge in research output suggests increasing recognition of the significance of LUTI models in addressing contemporary urban planning and transportation challenges. This documented trajectory underscores the dynamic nature of the field, reflecting the continuous exploration and adaptation of LUTI models to emerging needs, technological advancements, and evolving urban landscapes. The increasing number of publications over the years suggests a maturing field with expanding horizons and growing acknowledgement of the crucial role of LUTI models in shaping sustainable and resilient urban futures.

This analysis delves into the global distribution of scholarly documents related to LUTI model applications, offering insights into the countries and territories at the forefront of R&D. The United Kingdom and the United States stand out, with 13 documents each, reflecting their active involvement in exploring LUTI applications. France and Italy follow closely with 10 and six documents, respectively, indicating a robust interest in these European nations. China and Spain demonstrated a notable presence in the field with five documents each, while Australia, Belgium, and Greece contributed three documents each. The Netherlands, Canada, Germany, Saudi Arabia, and Switzerland exhibit moderate engagement, with two documents each. Several countries, including Colombia, Denmark, Hong Kong, Ireland, Japan, Luxembourg, Mexico, Poland, Singapore, Slovenia, South Africa, South Korea, Sri Lanka, and Taiwan, are represented in a single document.

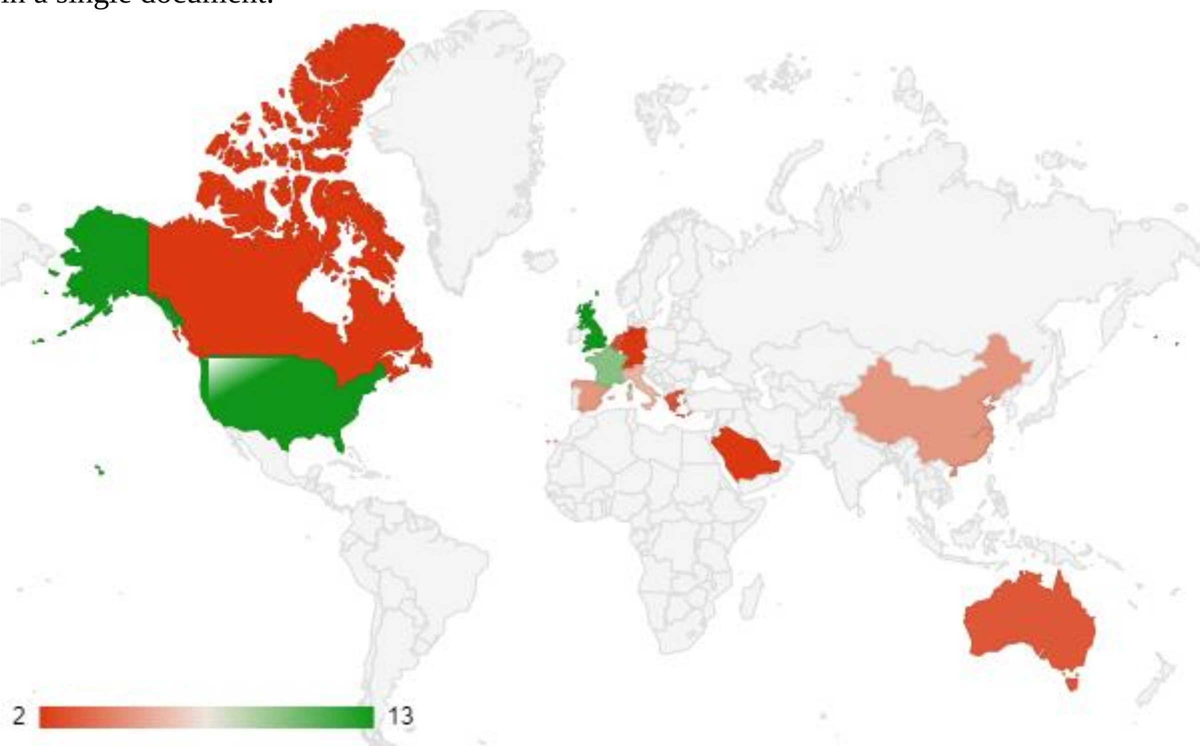

Fig. 4. Geographical distribution of Case Studies of the LUTI model.

This diverse geographical distribution underscores global interest and collaborative efforts in advancing LUTI applications, with potential implications for urban development and transportation solutions on an international scale.

The exploration of Land Use and Transportation Integration (LUTI) applications is well-represented in the academic literature, encompassing various document types that collectively contribute to the understanding and advancement of this interdisciplinary field. A total of 51 articles signify the depth and breadth of the original research dedicated to LUTI applications, highlighting diverse perspectives on the symbiotic relationship between land-use patterns and transportation infrastructure. Conference papers 7 underscore active scholarly engagement and disseminate new insights within academic circles. Reviews comprising five documents provide critical syntheses of existing knowledge and offer valuable perspectives on the state of LUTI application research. Additionally, a single book chapter enriches the discourse by comprehensively exploring LUTI applications in the broader context of urban planning and transportation studies.

This varied array of document types reflects the dynamic and evolving nature of LUTI application research, showing a combination of empirical studies, collaborative discussions, and comprehensive reviews that collectively contribute to the growth of knowledge in this critical field.

LUTI Model – Mathematical Expression

The **Land Use Transportation Interaction (LUTI) model** is a type of integrated urban model that simulates the two-way relationship between land use (e.g., residential, commercial, and industrial activities) and transportation systems (e.g., roads and transit networks). These models are particularly useful for evaluating the impact of land-use policies and infrastructure investments on urban growth, travel demand, and accessibility over time.

Core Concept:

The LUTI model captures the feedback loop.

- Land use patterns affect the travel demand.
- Transportation systems affect accessibility.
- Accessibility influences land-use decisions.

Generic Mathematical Framework

A typical LUTI model integrates these two systems.

1. Land Use Submodel

This simulates the location decisions of the households and firms.

Residential Location Utility (U_{rh})

$U_{rh}=\beta_1 C_{rh}+\beta_2 A_{rh}+\beta_3 E_{rh}+\varepsilon_{rh}$

Where:

- U_{rh}: Utility of household hhh choosing residence at location rrr
- C_{rh}: Cost of living/housing at location rrr
- A_{rh}: Accessibility of rrr (derived from transportation model)
- E_{rh}: Environmental/amenity variables
- ε_{rh}: Random error (to capture unobserved preferences)

Discrete Choice Formulation (logit)

P_{rh}=

$$Prh = \frac{\mathrm{eUrh}}{\sum \mathrm{keUkh}}$$

A similar equation can be developed for a form location choice.

2. Transportation Submodel

This uses **travel demand models** (often four-step or activity-based) to simulate travel flows based on land use patterns.

Step: Trip Distribution (Gravity Model)

$$\boldsymbol{Tij = k.\frac{Pi \cdot Ej}{f(Cij)}}$$

Where:

- Tij: Trips from zone iii to zone jjj
- Pi: Trip production (based on land use)
- Ej: Trip attraction

- f(cij): Travel impedance (often exponential or power function of travel time/cost)

Step: Mode Choice (Logit)

$$P_{ij}^{(m)} = \frac{e^{V_{ij}^{(m)}}}{\sum_m e^{V_{ij}^{(m)}}}$$

Where $V_{ij}^{(m)}$ is the utility of mode m for travel between i and j, based on time, cost, and socio-economic variables.

3. Accessibility Indicator

Key linkages from transport back to land use.

Example: Hansen-type accessibility index

$$Ai = \sum_j \frac{Ej}{f(Cij)}$$

Where:

- Ai: Accessibility of zone i
- Ej: Opportunities (jobs, amenities) in zone j
- cij: Travel cost/time between iii and j

Interaction Process

The LUTI model iteratively updates

1. Land use → generates population/jobs → produces trips
2. Transportation model → assigns trips → calculates accessibility
3. Accessibility → affects utility in land-use model → updates land use

This is repeated over time (e.g., every five years in the planning horizon).

Table 1: Common LUTI Model Examples

Model Name	**Key Features**	**Mathematical Base**	**References**
MEPLAN	Land-use and transport in equilibrium	Entropy-maximizing; Input-output economics	(Lopane et al., 2023)
TRANUS	Integrated urban and regional simulation	Logit models for choice behavior	(Johnston & De La Barra, 2000)
DELTA	Dynamic land-use forecasting	Discrete choice models + economic factors	(Sarri et al., 2023)
UrbanSim	Microsimulation-based LUTI model	Agent-based + econometric choice models	(Parishwad et al., 2023)

Below is a tabular analysis table for the methodology and applications of the LUTI (Land Use and Transportation Interaction) model:

Table 2: Methodology and applications of the LUTI (Land Use and Transportation Interaction) model

Aspect	Methodology	Applications
Model Type	• Integrated modeling of land use and transportation processes, often agent-based or cellular automata	• Urban and regional planning
Data Sources	• Census data, land use data, transportation networks, household surveys, economic indicators	• Future scenario planning and Transportation policy analysis
Spatial Scale	• Entire cities or regions)	• Urban and regional scale analysis Transportation network optimization
Temporal Scale	• Short to long-term (daily patterns to several decades)	• Forecasting land use changes over time. • Evaluating the impact of transportation projects
Components	• Land use allocation • Transportation network modeling • Agent-based modeling of individual behavior	• Transportation demand modeling • Accessibility and connectivity analysis • Impact assessment of policy interventions
Integration	• Simultaneous modeling of land use and transportation processes, feedback loops between the two	• Coordination of land use and transportation plans
Challenges	• Data integration challenges	• Calibration and validation of the model
	• Computationally intensive	• Handling uncertainties in future projections
Advantages	• Captures interactions between land use and transportation dynamics • Provides a holistic view of urban systems	• Supports informed decision-making in urban and transportation planning • Enables scenario testing and policy analysis
Limitations	• Sensitivity to input data quality and assumptions • Model calibration challenges	• Complexity may require specialized expertise • May not account for dynamic social behaviors

This table provides a structured overview of the methodology and applications of the LUTI model,
highlighted key aspects such as model type, data sources, spatial and temporal scales, components, integration, challenges, advantages, and limitations.

Data Requirements

The Land Use Transportation Interaction (LUTI) model relies heavily on accurate and comprehensive data to capture and simulate the complex relationships between land use patterns and transportation systems in urban areas (Adhvaryu & Kumar, 2021). The data requirements of LUTI models are crucial for ensuring the reliability, accuracy, and relevance of model outputs. The following are the key data requirements for effective LUTI modeling.

Land Use Data: LUTI models require detailed land use data to represent the spatial distribution and characteristics of the different land use types within the study area. This includes information on residential, commercial, industrial, and institutional land use, open spaces, and transportation infrastructure. Land use data should ideally include land area, building density, floor area ratios, and employment density (Nuissl & Siedentop, 2021).

Transportation Network Data: Accurate representation of transportation infrastructure is essential for LUTI models. This includes detailed data on road networks, such as information on link lengths, capacities, speed limits, and connectivity. In addition, data on public transportation networks, such as bus and rail systems, including route information, service frequencies, and stop locations, are essential for capturing the multimodal nature of transportation systems (Deepa et al., 2022).

Travel Behavior Data: To simulate travel patterns and mode choice, LUTI models require data on travel behavior, including origin-destination matrices, trip frequencies, trip purposes, and mode shares. These data provide insights into commuting patterns, trip lengths, travel times, and mode preferences, enabling models to capture realistic travel demand (Wan et al., 2019).

Socioeconomic data: Socioeconomic data are essential for understanding the demographic and economic characteristics of the study area and their influence on land use and transportation interactions. This includes data on population distribution, household size, income level, employment sector, and other socioeconomic indicators. Socioeconomic data provide insights into travel behavior, residential location choices, and employment patterns (Jain & Tiwari, 2019).

Policy and Intervention Data: LUTI models often incorporate the impacts of policy interventions and land-use regulations on land-use and transportation dynamics. Data on existing and proposed policies, zoning regulations, development plans, and transportation investments are necessary to simulate the effects of policy scenarios accurately. These data enable the evaluation of alternative planning, policy options, and their potential implications (Sarri et al., 2023).

Environmental and Infrastructure Data: Environmental factors, such as air quality, noise levels, and accessibility to amenities, are increasingly essential considerations in LUTI modeling. Data on environmental indicators, infrastructure conditions, and accessibility measures, such as proximity to parks, schools, healthcare facilities, and retail centers, enhance the ability of the model to assess the impact of land use and transportation on environmental sustainability and quality of life (Rao et al., 2021).

Calibration and Validation of LUTI model

Calibration and validation are essential in developing and applying Land Use Transportation Interaction (LUTI) models. Calibration involves adjusting the model parameters and inputs to ensure that the simulated outputs accurately represent real-world conditions. Conversely, the validation assesses the model's performance by comparing its outputs with the observed data. Both calibration and validation are critical for enhancing the reliability and predictive power of the LUTI models.

Calibration:

Calibration involves adjusting the model parameters and inputs to match the observed behavior and conditions in the study area. The calibration aims to minimize the discrepancy between the model outputs and observed data, ensuring that the model accurately represents the relationship between land use and transportation. Standard calibration techniques include trial-and-error adjustments, optimization algorithms, and statistical methods.

Various model parameters were adjusted during calibration to align the simulated outputs with the observed data (Mai, 2023). These parameters may include travel demand elasticities, mode choice probabilities, network assignment parameters, and land use change coefficients. Calibration may also involve adjusting the input data, such as trip matrices or land-use data, to better fit the observed conditions (Najmi et al., 2020).

Validation:

Validation is the process of evaluating the performance of a calibrated model by comparing its outputs against independent and representative observed data. This step helps to assess the model's ability to replicate real-world conditions and measure its reliability and predictive accuracy. Validation data include travel surveys, census data, traffic counts, and other relevant sources (Aschauer et al., 2021).

Validation involves comparing model outputs such as travel times, mode shares, traffic volumes, and land-use patterns with observed data. Statistical techniques such as goodness-of-fit measures, error metrics, and hypothesis tests are commonly used to quantify the level of agreement between model outputs and observed data. Successful validation indicates that the model has captured the key relationships and dynamics between land use and transportation in the study area (Raj & Sharma, 2022).

Iterative Process:

Calibration and validation are typically iterative processes that involve multiple adjustments and evaluations. The modelers refine the model's parameters and inputs based on the results of the validation process. This iterative approach helps improve the performance of the model and ensures that it accurately represents the unique characteristics and dynamics of the study area (Najmi et al., 2020).

Sensitivity Analysis:

Sensitivity analysis is an essential component of the calibration and validation processes. This involves systematically varying the model inputs and parameters to assess their impact on its outputs. Sensitivity analysis helps to identify the most influential factors and parameters, providing insights into the robustness and uncertainty of the model. This allows modelers to understand the sensitivity of the model's results to different assumptions and can guide further refinements and improvements (Basu & Ferreira, 2020).

Simulation:

LUTI models simulate the interactions between land use and transportation systems over time, accounting for various factors, such as travel demand, mode choice, and transportation infrastructure. Simulating these interactions at acceptable spatial and temporal resolutions is computationally demanding. Large-scale urban areas and long-term simulations require significant computational resources to accurately capture the complexities and dynamics of urban systems (Le et al., 2023).

Computation Time:

The computational complexity of LUTI models can also affect the time required to run the simulations and generate results. Simulating an urban area's land use and transportation dynamics can be time-consuming, particularly when considering a large study area or a long-term timeframe. The computational time required can limit the feasibility of real-time or near-real-time decision support, hindering the integration of LUTI models into the planning processes (Batty & Milton, 2021).

Data Processing:

The computational complexity extends beyond the simulation to data-processing tasks. Preprocessing and integrating diverse datasets, such as land use, transportation networks, and travel behavior data, can be challenging and time consuming. Data cleaning, geocoding, network assignment, and spatial analysis add to the computational workload (Karami and Kashef, 2020).

Sensitivity Analysis and Scenario Testing

Sensitivity analysis and scenario testing are crucial steps in LUTI modeling. These tasks involved iteratively running the model with different inputs and parameters to evaluate their impact on the outputs. Sensitivity analysis and scenario testing can require multiple runs of the model, which further adds to computational complexity (Sarri et al., 2023).

Model Calibration and Optimization

Calibrating LUTI models often involves optimization techniques to find the best set of model parameters that minimize the discrepancy between the simulated and observed outputs. Optimization algorithms can be computationally demanding, particularly when dealing with large parameter spaces and complex objective functions. To achieve convergence, the calibration process may require running the model multiple times with different parameter values (Kii et al., 2019).

Various strategies can be employed to mitigate the computational complexity of LUTI models. These include utilizing parallel computing techniques, optimizing algorithms, and leveraging high-performance computing resources. Additionally, simplifying model structures, reducing data resolution, and using surrogate models or model approximations can help manage computational demands while maintaining the model accuracy to an acceptable level (Rong & Jin, 2023). In summary, the computational complexity of LUTI models arises from the need to process large datasets, simulate complex urban systems, and conduct sensitivity analyses and scenario testing. The computational resources required for model development, simulation, and data-processing tasks can be substantial. Managing computational complexity is essential to ensure the efficiency and feasibility of LUTI modeling, enabling its integration into urban planning and policy-making processes (Gavanas et al., 2016).

Interpretations

The Land Use Transportation Interaction (LUTI) model has emerged as a valuable tool for analyzing the complex relationships between land-use patterns and transportation systems in urban areas. While LUTI models offer significant potential for informing urban planning and policymaking, a critical review reveals several limitations and challenges that must be addressed for effective application. One of the main challenges of LUTI models is their data requirements. These models rely heavily on accurate and comprehensive data, including land use surveys, transportation networks, travel behavior data, and socioeconomic indicators. However, acquiring such data at an appropriate level of detail and granularity can be time consuming and costly. These models require robust calibration techniques to ensure that the simulated outputs accurately represent the real-world conditions. However, the calibration process can be challenging owing to the complex and dynamic nature of land-use and transportation interactions.

Furthermore, the validation of LUTI models against observed data is often limited because obtaining comprehensive and reliable validation datasets can be difficult (Cordera et al., 2021). The computational complexity of LUTI models is another concern. Simulating land use and transportation interactions at fine spatial and temporal resolutions requires significant computational resources. This poses challenges for both model development and application, particularly for larger urban areas or long-term scenarios. The computational burden may limit the feasibility of real-time decision support or hinder the integration of LUTI models into the planning processes.

LUTI models also face limitations in capturing the full range of factors that influence land-use and transportation interactions. While these models commonly consider travel demand, mode choice, and transportation infrastructure, they may overlook important socioeconomic, cultural, and environmental factors that shape urban dynamics. Integrating additional dimensions such as social equity, environmental sustainability, and community preferences can enhance the comprehensiveness and relevance of LUTI models (Jones et al., 2017). The temporal dimension is another area that requires attention in LUTI modeling. Land use and transportation systems evolve over time, and capturing temporal dynamics is crucial for understanding long-term impacts and policy effectiveness. However, many LUTI models cannot incorporate dynamic changes such as demographic shifts, economic fluctuations, or policy transitions. Incorporating temporal dynamics would enhance the predictive power of the models and enable more robust scenario analysis (Coppola et al., 2013). Furthermore, the interpretation and communication of LUTI model results pose challenges. LUTI models produce complex outputs, often in spatial maps, charts, and graphs, which may be difficult for nontechnical stakeholders to comprehend. Translating the model results into actionable insights for policymakers and effectively communicating the implications of alternative scenarios require clear and accessible presentation methods. In brief, although LUTI models offer valuable insights into land use and transportation interactions, a critical review reveals several limitations that need to be addressed. Overcoming data limitations, improving calibration and validation techniques, managing computational complexity, incorporating additional dimensions, capturing temporal dynamics, and enhancing result interpretation and communication are crucial areas for future research. By addressing these challenges, LUTI models can become more reliable, comprehensive, and user-friendly tools for supporting sustainable urban planning and policy making.

Conclusions

In conclusion, Land Use Transportation Interaction (LUTI) models present challenges and opportunities in urban planning and transportation research. The challenges stem from various factors, including the complexity of the models, data limitations, interpretation biases, technicality of results, and uncertainties associated with the assumptions and data. However, these challenges can be addressed through transparency, stakeholder engagement, effective communication, and the limitations and uncertainties of models. Despite these challenges, LUTI models offer significant opportunities to improve our understanding of the interactions between land-use patterns and transportation systems. These models provide a holistic framework to analyze the long-term impacts of land use and transportation decisions, evaluate policy interventions, and explore future scenarios. They help decision-makers identify the consequences of different planning options, assess the sustainability of urban development, and support evidence-based decision making. LUTI models offer the potential to integrate spatial and temporal dynamics, incorporate socioeconomic and environmental factors, and assess the multidimensional impacts of urban growth. They can guide the development of more sustainable and efficient land-use and transportation systems, promote equitable access to opportunities, and address environmental challenges.

Furthermore, LUTI models create opportunities for stakeholder engagement and collaboration, facilitating a participatory approach to urban planning and policymaking. By involving various stakeholders, including government agencies, community groups, and the private sector, LUTI models can incorporate diverse perspectives, preferences, and priorities, leading to more inclusive and effective decision-making processes. Advancements in data collection methods, computational power, and modeling techniques offer further opportunities for enhancing the accuracy and reliability of LUTI models. Integration with emerging technologies, such as machine learning and big data analytics, can improve the quality of input data, enhance model calibration and validation, and support real-time decision-making. To maximize the potential of LUTI models, ongoing research, interdisciplinary collaboration, and knowledge exchange are essential.

Continuous efforts to improve data quality, refine model structures, address limitations, and enhance interpretation and communication strategies will enable the practical application of LUTI models in urban planning. In conclusion, although challenges exist, the opportunities provided by LUTI models outweigh them. By addressing the challenges of transparency, stakeholder engagement, and effective communication, LUTI models can contribute to sustainable and equitable urban development, inform policy decisions, and help shape livable and resilient cities.

Declarations

The authors declare that they have no conflicts of interest. This study received no funding.

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