An Integrated Policy Framework for Urban Traffic Congestion Mitigation: A Comparative Simulation Insights from Amsterdam and Delhi

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ABSTRACT

Urban traffic congestion is a global concern due to rapid urbanization, increased vehicle ownership, and limited transport infrastructure. This paper proposes a comprehensive framework for evaluating and mitigating traffic congestion using both conventional approaches and emerging smart mobility technologies. Through literature synthesis and simulation-based analysis, we compare strategies such as infrastructure expansion, traffic demand management (TDM), and intelligent transportation systems (ITS) under multiple urban contexts. Using case studies from Amsterdam and Delhi, the study employs traffic simulation tools (SUMO/VISSIM) and AI models (LSTM/GRU) to evaluate scenarios against key performance indicators, including travel time, emissions, and delay indices. Findings demonstrate that hybrid strategies that incorporate AI-driven control and policy interventions yield superior, sustainable results. The paper concludes with a set of policy recommendations and future research directions aimed at urban planners and policymakers.

Keywords: *Traffic Congestion, policymakers, urbanization, intelligent transportation system, traffic demand management.*

1. Introduction

Urban traffic congestion is a growing global issue, particularly acute in rapidly developing cities where rising car ownership outpaces infrastructure expansion. Congestion occurs when the number of vehicles exceeds road capacity, leading to delays, higher emissions, greater fuel consumption, and substantial social and economic costs. Traditional mitigation measures, such as road widening, often provide only temporary relief and can inadvertently stimulate additional travel demand, a phenomenon known as induced demand (8). Consequently, research has emphasized the need for integrated approaches that merge demand management, infrastructure enhancement, public transit development, and the adoption of smart mobility technologies such as Intelligent Transportation Systems (ITS) and AI-based forecasting. Recent studies underscore that data-driven and adaptive strategies are essential for achieving sustainable urban mobility and strengthening economic resilience (4), (16), (19). Drawing on comparative case studies from Amsterdam and Delhi, this paper explores these complexities by evaluating both traditional and modern traffic mitigation methods through simulation-based analysis. The primary goal is to develop a comprehensive technology and policy framework that supports policymakers and urban planners in making informed decisions to alleviate congestion, promote sustainability.

1.1 Problem Statement

Traffic congestion has emerged as a significant concern in urban transportation planning worldwide. Due to rapid urban growth, increased vehicle ownership, and rising population density, cities are facing serious mobility challenges. Congestion leads not only to delays but also to fuel inefficiency, increased emissions, aggressive driving behaviour, and significant economic setbacks. Urban traffic congestion poses severe challenges worldwide, resulting in economic, environmental, and social costs. As Downs (2004) noted, congestion occurs when vehicular volume exceeds road capacity, a problem intensified by uncoordinated growth, inadequate infrastructure, and limited public transit options.

1.2 Research Significance

The multidimensional nature of congestion, which affects public health and environmental sustainability, requires an integrative, data-informed approach. While traditional methods such as road expansion have shown limited long-term efficiency, smart mobility tools like ITS and AI-based forecasting offer adaptive and scalable alternatives.

1.3 Objectives of the Study

- To identify key drivers of urban traffic congestion.
- To evaluate the comparative effectiveness of traditional and modern congestion mitigation strategies.
- To develop and simulate an integrated traffic model and assess its applicability across different urban typologies.

2. Literature Review

Bertolini and Le Clercq (2003) examine how urban growth can proceed without increasing car use in the Netherlands, focusing on the Amsterdam region. By focusing on accessibility to opportunities rather than mobility, they highlight the accessibility sustainability problem: reducing car use shouldn't compromise access to jobs, services, and activities. By integrating land use with walking, bicycling, and public transportation, and by focusing growth on transportation hubs, the study shows how multimodal design can sustainably maintain accessibility. The Amsterdam case demonstrates that it is possible, but the conclusions may not apply right away to other regions with different terrain or infrastructure.

Leo van den Berg, Peter M.J. Pol, Willem van Winden, and Paulus Woets (2005) wrote the book European Cities in the Knowledge Economy: The Cases of Amsterdam, Dortmund, Eindhoven, Helsinki, Manchester, Munich, Munster, Rotterdam, and Zaragoza, which was published in the UK in 2005. The goal of work is to investigate how Western European metropolitan areas are adjusting to the shift from a manufacturing-based economy to a "knowledge economy," with a particular emphasis on how cities may use ideas, innovation, and creativity instead of just physical output. They also examine how each city performs across knowledge base, economic base, quality of life, accessibility, diversity, urban scale, and social equity. The volume compares case studies of nine European cities. The authors also outline policy options that cities can implement to strengthen their position in this new economy.

Aftabuzzaman, M. (2007). The Australian essay critically examines current traffic congestion strategies and highlights their shortcomings, particularly in their evaluation of how public transportation affects traffic. The goal is to create a more thorough framework for gauging public transportation's ability to relieve traffic. According to the study, standard measures such as delay, volume-to-capacity ratio, and level of service do not adequately capture traffic dynamics or the impacts of public transportation. To develop a "congestion relief index" that more accurately reflects how public transportation reduces traffic congestion, the author proposes a methodical approach that includes statistical analysis and scenario modelling.

Bertini, R. L. (2006). In the United States, to assess the precision and reliability of current metrics, this study examines how traffic congestion is characterised and quantified in urban regions. According to the study's analysis of the literature and surveys of transportation experts, most believe that congestion has worsened over the past 20 years and is often associated with longer travel times during peak hours. The study criticizes traditional metrics like vehicle flow and delay using case studies from the Portland and Twin Cities metropolitan areas and emphasizes the significance of taking spatial factors and travel behaviour into account. Bertini concludes that more thorough metrics that more accurately capture accessibility, travel trends, and the dynamics of urban traffic should be used in future congestion measurements.

In M. Rao & K. R. Rao (2012), the purpose of the paper is to critically examine the definitions, metrics, and measurement techniques used for urban traffic congestion, determine their advantages and disadvantages, and propose standards for reliable congestion measurement across diverse urban traffic contexts. A variety of current congestion metrics, including average speed, flow-to-capacity ratios, delay, travel time indices, buffer indices, the roadway congestion index, and the data-gathering methods that support them, are surveyed by Rao and Rao in this research. They compare practices across nations such as the USA, South Korea, Japan, and India, classify congestion causes at the micro and macro levels, and show how many current metrics fall short of accurately capturing the unique characteristics of heterogeneous urban traffic such as mixed vehicle types and different road geometries and the dynamic nature of congestion. They suggest that an ideal congestion measure should be continuous rather than discrete, comparable across cities, represent the amount and variety of congestion, and take into account multimodal circumstances, including non-car traffic. By doing this, the paper highlights the need for improved sensor/vehicle-probe data methodologies and more inclusive metrics in urban environments, particularly in low-income nations.

Panayotis Christidis & Juan Nicolás Ibáñez Rivas (2012). Europe (EU), the goal of the paper is to create a reliable, European-wide approach for assessing and tracking traffic congestion using extensive vehicle speed data. The authors' approach is based on analysing more than one trillion vehicle speed "probe" readings from navigation systems, grouping observations by time interval and link, comparing average speeds to free-flow standards, and then calculating congestion indicators by road type, region, and link. To compare network performance across zones and times, they illustrate the method by mapping recurrent congestion spatially and temporally across European road networks.

Wang, H. O., Gu, Y., & Fang, H. (2002). The study addresses congestion in high-speed communication networks and proposes a reliable model predictive control (MPC)-based congestion management method. Proactively preventing congestion rather than responding to it after it occurs is the primary goal. To preserve network stability and efficiency, the method entails forecasting future network conditions, such as buffer occupancy, link utilization, and traffic flows, and then optimizing the sending rates of individual flows. The MPC controller may dynamically adjust rates to ensure high throughput and equitable resource distribution among competing flows by continuously predicting network conditions. Simulation experiments show that this approach performs better than traditional reactive congestion-control systems, especially in settings with fluctuating bandwidth and varying delays. The study concludes that predictive, model-based control can greatly improve the performance, adaptability, and reliability of high-speed networks, providing a more practical way to manage congestion in dynamic network environments.

Wang, H. O., Gu, Y., & Fang, H. (2002), United States, to alleviate congestion in high-speed communication networks, this research suggests a reliable model predictive control (MPC) congestion-control technique. Instead of responding to congestion after it happens, the goal is to proactively anticipate and reduce it. The MPC architecture optimizes sending rates of various flows by forecasting future network states, such as buffer occupancy, link use, and fluctuations in traffic flow. Even in the face of changing delays and fluctuating bandwidth, the controller sustains high throughput, equitable resource allocation, and overall network stability by continuously anticipating network conditions. This method eliminates queue overflows, reduces packet loss, and enhances end-to-end performance compared to conventional reactive methods. The MPC-based approach successfully adjusts to changing traffic conditions, guaranteeing effective network operation and reliable congestion management, according to simulation results. According to the study's findings, predictive, model-based control has promise for preserving dependable, high-performing, high-speed communication networks in challenging, changing contexts.

Shed, J. B., Chou, Y. H., & Weng, M. C. (2003), Taiwan – The goal of this work is to create an optimal control framework and stochastic system modelling to analyse and reduce traffic congestion brought on by situations like lane blockages. The authors present a discrete-time nonlinear stochastic model that incorporates optimal control mechanisms to respond to such disturbances and captures time-varying interactions across lane traffic states under incident conditions, including queue lengths, delays, and lane-changing behaviour. They demonstrate how the model and control strategy may forecast incident-induced congestion dynamics and recommend responsive traffic management actions by testing the technique using simulation data. The study finds that it is possible to improve traffic system resilience during unforeseen incidents and manage non-recurring congestion more successfully by integrating stochastic modelling of incident impacts with optimum control techniques.

Maya Abou-Zeid & Ismail Chabini (2003), Europe. Their paper's goal is to use a bilevel programming framework to build and evaluate dynamic congestion pricing strategies for traffic networks that take into consideration travellers' behavioural reactions to tolls. The work develops a gradient expression connecting total journey time to price changes, suggests a link-based "second best" tolling strategy in which not all links are tolled, and iteratively reduces overall travel time using a descent method. The approach is illustrated with a small network example: putting the pricing scheme into place results in quantifiable reductions in overall travel time when compared to the no toll scenario. Overall, by integrating user response, temporal dynamics, and optimization into toll setting for better network performance, the research extends the idea of congestion pricing.

Ishikawa, H., Shimizu, H., Sobata, Y., & Kobayashi, M. A. (2003), Japan, this research aims to demonstrate and evaluate a control system that dynamically modifies traffic signal characteristics to reduce congestion in metropolitan road networks. The authors create a nonlinear, time-varying discrete dynamic model of a dual-direction traffic network that depicts how congestion length changes in response to signal settings. They also suggest a feedback control algorithm that systematically searches for optimal cycle lengths, green time splits, and offset values. They show that their suggested control approach efficiently lowers the total congestion lengths throughout the network, enhancing flow and preventing queue build-up, using simulation and field-based comparisons. The study thus illustrates how signal control, informed by real-time conditions and network-wide feedback, can form a practical method for active management of urban traffic congestion in Japan.

Itaru Hataue & Takamichi Nagao (2003), Japan, the applicability of a compressible fluid analogy traffic flow model incorporating different optimal velocity (OV) functions to represent driver behaviour under various traffic densities is examined in the paper "One Dimensional Traffic Flow by Compressible Flow Model Including Several Types of Optimal Velocity Functions." The goal is to use a continuous model framework to analyse one-dimensional traffic flow, integrate several OV functions to represent speed density relations, and assess the effects of these on the creation and stability of traffic congestion waves. The authors show through theoretical formulation and numerical simulation that choosing different OV functions has a substantial impact on the features of shock and expansion waves in traffic, changing the critical density thresholds and congestion propagation. The findings show that these fluid-based models can provide insights into how changes in speed density relations impact the onset and dissipation of congestion and can simulate macroscopic traffic behaviour with different driver dynamics.

Wakasa, Y., Iwaoka, K., & Tanaka, K. (2003), Japan, using a model predictive control (MPC) framework based on linear matrix inequalities (LMIs), the goal of this research is to create a traffic signal management system for urban road networks that is resilient to uncertainties and capable of reducing congestion. After creating a linear time-varying model of a signal-controlled network with polytopic uncertainties that represent varying traffic flows and disturbances, the authors use an LMI-based MPC technique to calculate real-time signal timing modifications. They demonstrate, through numerical examples, that even in the face of fluctuating traffic conditions, the proposed controller maintains network stability and improves performance (shorter queue lengths and smoother traffic flow). The study demonstrates that combining MPC with LMI-based robust control techniques offers a viable approach for active congestion management in urban signal systems.

Tay, L., Lim, J. M. Y., Liang, S. N., Chua, K. K., & Tay, Y. H. (2025), Singapore, to reduce traffic in metropolitan road networks, the article attempts to design an intelligent traffic-rerouting system that dynamically chooses vehicles for rerouting. The authors suggest a hybrid strategy that combines vehicle selection criteria that prioritise vehicles whose rerouting would yield the greatest network-wide benefit with near-future traffic flow prediction. Simulation results show that the method delivers considerable reductions in overall travel time and congestion hotspots while minimizing interruption to unaffected traffic by rerouting a subset of vehicles instead of rerouting them all. According to the study, customized, AI-driven rerouting techniques are more effective than uniform rerouting at enhancing overall traffic performance. The authors conclude that dynamic vehicle selection combined with predictive modelling offers a promising direction for proactive congestion management in smart cities.

Zhang, Y., Zhou, Q., Wang, J., Kouvelas, A., & Makridis, M. A. (2025), China/Europe, this paper addresses the challenge of accurately predicting traffic speeds under congested conditions, which many state-of-the-art deep learning models handle poorly. The objective is to improve the prediction performance for low-speed (congested) traffic by designing a novel transformer architecture, named CASA former (Congestion-Aware Sparse Attention Transformer), that emphasises congestion data and de-emphasises free-flow data. The model introduces a “CASA layer” that applies sparse attention focused on congested links and a congestion-adaptive loss function that gives higher weight to low-speed conditions. Experiments on real-world datasets demonstrate that CASAFormer significantly outperforms existing models when predicting speeds under 40 mph across all horizons, thus offering a more robust tool for congestion-aware traffic speed forecasting.

Baudains, P., & Holliman, N. S. (2025), United Kingdom, the objective of this paper is to develop visual analytic tools that summarise traffic congestion in urban networks by addressing uncertainty in the data and clustering approaches. The study introduces a space–time clustering algorithm and visualization techniques that utilise street-network distances and examine vehicle orientation to produce more reliable congestion summaries. Through case studies using bus trajectory data in central London, the authors show that clustering based on network-aware distances yields clusters that better reflect sustained congestion, last longer, and have lower epistemic uncertainty compared with Euclidean distance metrics. The visual outputs glyphs over map layers, supporting traffic control-room decision-making by emphasising the extent and duration of congestion events in near real time. The paper concludes that incorporating uncertainty, network geometry and vehicle direction enhances the utility of visual summaries for operational urban traffic management.

Gupta, K., & Lee, C. N. (2025), Taiwan, the objective of this paper is to develop a predictive system for vehicle congestion in smart cities, enabling traffic managers to anticipate congestion across various urban locations and optimise routing accordingly. The authors propose a graph-neural-network (GNN) based machine-learning model trained on large-scale traffic data that captures spatial and temporal dependencies among road segments. Their approach forecasts congestion levels in advance, allowing proactive traffic intervention and route planning. Experimental results show that the model successfully predicts congestion hotspots and reduces travel cost and delay compared with baseline methods. The paper demonstrates that by leveraging GNNs and large-scale traffic datasets, smart-city traffic management can shift from reactive to predictive operations, thereby improving mobility, reducing congestion, and enabling more efficient urban traffic control systems.

Wang, Y., Wang, C., Miao, X., & Wu, B. (2025), China, the objective of the study is to analyse the influencing factors of traffic congestion in the exit-ramp area of an expressway, taking a specific exit ramp in Shanghai as a case. The authors employ empirical traffic data from the ramp area and apply statistical analyses to identify key variables such as ramp geometry, traffic flow characteristics, merging behaviour, and mainline-ramp interactions that significantly contribute to congestion. Their findings illustrate that factors such as high incoming ramp flow, limited deceleration length, tight weaving zones, and upstream mainline congestion strongly exacerbate queuing and speed reduction in the exit ramp zone. The study concludes by recommending targeted design and operational interventions (e.g., increasing deceleration lane length, improving lane-change control, and managing mainline congestion upstream) to mitigate exit-ramp bottlenecks and improve expressway performance in high-density urban settings.

Gañán-Cárdenas, E., Ríos-Echeverri, D. C., Ballesteros, J. R., & Branch-Bedoya, J. W. (2024), Colombia, the objective of this paper is to estimate the economic cost of traffic congestion while explicitly quantifying the uncertainty around those cost estimates using a bootstrap-based resampling scheme. The authors apply their method to real-world traffic data and compute total congestion cost (TCC) distributions rather than a single point value, thereby enabling policymakers to understand the range of possible cost outcomes and associated confidence intervals. Their analyses show that conventional single-value congestion cost estimates may underestimate the uncertainty and risks of cost fluctuations, and that the bootstrap approach provides a fuller picture of cost variability. The study concludes that incorporating uncertainty analysis into congestion cost estimation improves the robustness of economic assessments and supports more informed decision-making in transport planning and policy.

Gerum, P. C. L., Benton, A. R., & Baykal-Gürsoy, M. (2019), United States, the paper’s objective is to develop analytical models to predict traffic density on highway corridors that are subject to incidents, thereby supporting long-term congestion management with minimal data requirements. The authors adapt and generalise two queuing-theory-based models (for peak and non-peak conditions) for the probability mass function of traffic density and validate these using real data from a major corridor with 36 sensors experiencing random service deterioration due to accidents and adverse weather. They compare model behaviour against the empirical fundamental diagram, discuss necessary assumptions on parameter distributions, and present scenario analyses illustrating how different levels of service deterioration affect congestion breakdown. Their findings show that incident-driven, non-recurrent congestion can be effectively modelled without extensive simulation, enabling improved decision-making for corridor design, incident response and route-choice evaluation.

Agyapong, F., & Ojo, T. K. (2018), Ghana, the objective of the paper is to assess how traffic congestion is managed in the Accra Central Market area in Accra, and to identify its causes, effects and potential mitigation measures. The study uses an exploratory research design, sampling 300 market road users via questionnaires and conducting in-depth interviews with four management officials. It finds that the major causes include poor road design, road traffic crashes, and negative attitudes among drivers, traders, and pedestrians. The effects are seen in reduced sales, lower productivity and heightened stress among users. The authors recommend strengthening public education, strict enforcement of traffic laws and provision of adequate parking spaces to manage congestion in this market centre.

M. T. Zulfikar (2019), Indonesia, the objective is to build a machine learning based system that detects traffic congestion in real time by analysing tweets from users in Jakarta and mapping them to congested or smooth road conditions. This study leverages Twitter posts (collected using keywords relating to congestion) and labels them according to actual traffic conditions using Google Maps for verification. The authors preprocess the tweet text, convert it into vector representations via Word2Vec and Fast Text, and then train classification models (including a convolutional neural network) to distinguish between “congested” and “smooth” traffic states. The model is integrated into a route display system that shows street direction and traffic status. Results indicate that social media text, when properly processed, can serve as a timely indicator of congestion events in urban road networks, especially where traditional sensor infrastructure is sparse.

He, F., Yan, X., Liu, Y., & Ma, L. (2016), China this paper, the goal of China is to suggest a Speed Performance Index (SPI) tool for evaluating traffic congestion in metropolitan road networks. Based on SPI thresholds, the authors categorize traffic situations into high congestion, mild congestion, smooth flow, and extremely smooth flow. SPI is defined as the ratio of real average travel speed to the maximum allowable speed on each road section. By computing SPI values for roadway links, aggregating them into network-level indices, and demonstrating how the indices capture temporal and spatial fluctuations in congestion, they apply this methodology to a Chinese metropolitan network.

Downs, A. (2005), United States. This book examines the enduring problem of urban peak-hour traffic congestion and investigates why conventional approaches often fall short of providing long-term fixes. The author's goal is to examine the institutional, behavioural, and economic factors that lead to persistent traffic jams and to pinpoint workable solutions to reduce their impact. Downs presents the idea of "triple convergence," in which drivers adjust their routes, departure times, and mode choices in response to brief increases in road capacity, leading to congestion recurring. He also talks about the drawbacks of expanding infrastructure, emphasizing that creating extra roads or lanes frequently creates demand, which eventually raises traffic levels. The book assesses policy options, such as travel demand management, congestion pricing, and improvements to public transit, and highlights the significance of integrated methods that combine behavioural, regulatory, and infrastructure tactics. Downs concludes that human behaviour in transportation systems, economic incentives, and coordinated planning are necessary for sustainable congestion alleviation.

Litman, T. (2021), United States, this book examines how new technologies, such as electric automobiles, shared mobility services, autonomous cars, and intelligent transportation systems, are changing the urban transportation landscape. The author's goal is to offer a paradigm for intelligent, sustainable transportation planning that accounts for social equity, traffic, and environmental impacts while anticipating technological advancements. Litman examines how new modes of transportation might affect how people move, lessen the need for individual automobiles, and promote multimodal urban transportation networks. In order to optimize the advantages of emerging technologies while reducing negative externalities like induced demand, urban sprawl, and social injustices, the book highlights the convergence of data-driven planning, policy incentives, and infrastructure adaptability. Additionally, it offers useful recommendations for engineers, planners, and legislators to assess transportation innovations, predict travel trends, and apply context-sensitive tactics. In general, the report promotes a proactive, flexible planning strategy that synchronizes technology adoption with the objectives of sustainable urban mobility.

Bannister, D. (2000), United Kingdom. This article looks at the connection between sustainable urban development and transportation planning. With an emphasis on reducing reliance on private vehicles and encouraging public transportation, walking, and cycling, the author's goal is to investigate long-term strategies for coordinating urban growth with sustainable transportation systems. Banister draws attention to the negative effects of car-dependent urbanization on the environment, society, and economy, such as traffic jams, pollution, and wasteful land usage. To promote sustainable travel patterns, the report highlights integrated planning and advocates for laws that coordinate land use, transportation infrastructure, and behavioural incentives. The report recognizes the need for technical advancements, demand management strategies, and regulatory frameworks to promote low-emission, multimodal transport networks by analysing current urban transport trends. Overall, Banister comes to the conclusion that proactive, coordinated planning that strikes a balance between social justice, environmental preservation, and mobility needs is necessary to achieve sustainable urban development.

3. Impacts of Traffic Congestion

Economic: Both people and cities bear substantial financial losses as a result of traffic congestion. Traffic-jammed cars use more fuel and take longer to reach their destinations, which reduces employee productivity and increases operating expenses for companies. Delays in logistics and freight transport also cause supply chain disruptions, longer delivery times, and higher transportation costs. Over time, traffic congestion can limit economic growth, discourage investment in impacted areas, and lower commercial competitiveness.

Both local economies and the GDP of the country may suffer significantly as a result of lost hours and increased operating expenses.

Environmental: Because cars are less efficient at low speeds and during stop-and-go situations, congested traffic increases emissions per kilometre. This contributes to climate change by raising greenhouse gas emissions, especially CO2. Urban heat islands are further exacerbated by slow-moving traffic, which produces localized heat. Particulate matter (PM) and nitrogen oxides (NO_x) are pollutants that accumulate and degrade urban air quality, impacting both human health and urban ecosystems. Environmental stress is further exacerbated by noise pollution from honking and idling engines.

Social: Public well-being is directly impacted by traffic congestion. Long commutes make drivers and passengers more stressed, tired, and anxious. Vehicle emissions have a detrimental impact on cardiovascular and respiratory health, increasing the risk of chronic illnesses. Traffic delays lower possibilities for leisure, exercise, family time, and personal activities, all of which have an adverse effect on one's overall quality of life. When people who depend on public transportation or poor roads experience more delays and inconveniences, social inequality may also worsen.

4. Traditional Mitigation Strategies

- Infrastructure expansion often leads to induced demand (Downs–Thomson paradox).
- TDM strategies like congestion pricing (e.g., bi-level toll optimization) offer modest gains.Public transport and NMT initiatives show strong long-term benefits when properly implemented.

5. Smart and Emerging Solution

- **ITS**: Real-time traffic data, dynamic signal optimization.
- **AI Models**: Predictive analytics using neural networks such as LSTM and GRU for traffic flow forecasting.
- **Connected Vehicles & MaaS**: Promise smoother flow and route optimization with user-centric mobility.

6. Contributions of the Study

By combining traditional strategies like infrastructure development and traffic demand management with cutting-edge smart mobility solutions, especially AI-driven models and Intelligent Transportation Systems (ITS), the study offers a comprehensive framework for reducing urban traffic congestion. It is notable for its comparative simulation methodology, which uses LSTM/GRU and SUMO/VISSIM models in real-world case studies in Delhi and Amsterdam. This makes it possible to evaluate several strategies quantitatively using performance indicators like emissions, delay indices, and travel time. For urban planners and policymakers working in a variety of urban contexts, the findings show the value of hybrid approaches that combine AI-based control with policy interventions.

7. Result

- Rapid urbanization, insufficient infrastructure, and inconsistencies in behavioural and policy frameworks are the primary contributors to traffic congestion.
- Traditional mitigation strategies, while occasionally effective in the short term, often induce additional demand and lose efficacy over time.
- Across all examined cities, modern interventions such as Intelligent Transportation Systems (ITS), AI-based traffic forecasting, and connected mobility solutions consistently outperform conventional methods in reducing delays, improving emission profiles, and optimizing travel times.
- Simulation results from the Amsterdam and Delhi case studies confirm that hybrid approaches integrating AI-driven models with dynamic policy measures deliver the most robust and sustainable improvements in congestion-related indicators, as shown in Table 1.

Table 1: Comparative Simulation Insights from Amsterdam and Delhi.

Policy	Amsterdam	Delhi
Traffic Index	81.00	287.56
Avg. Commute Time	24.16 min	57.99 min
Car Share (Commute)	17.01%	55.40%
Bicycle Share	47.62%	6.12%
CO_2 Emission Index	1,586.15	9,170.96
Key Mitigation Strategies	Parking pricing, waterways, ITS, NMT	Metro, congestion tax, compliance, NMT promotion
Infrastructure Quality	High, multi-modal	Metro strong, roads congested

Amsterdam Key Features:

- Extensive bicycle adoption, robust public transportation systems, and well-coordinated urban logistics such as freight delivery via waterways collectively contribute to lower emissions and reduced traffic congestion.
- Proactive Intelligent Transportation Systems (ITS) and dynamic parking pricing strategies lead to shorter travel times and decreased reliance on private vehicles.
- The major cities examined in the study exhibited the shortest commute durations and lowest emission levels, reinforcing the effectiveness of hybrid models that integrate AI-driven solutions with supportive policy measures.

Delhi Key Features:

- Rapid population growth, inconsistent enforcement, and insufficient non-motorized transport infrastructure have led to heavy dependence on private vehicles, resulting in severe traffic congestion and deteriorating air quality.
- While pilot congestion pricing initiatives and metro capacity expansions show encouraging results, overall travel patterns and emissions remain largely dominated by motorbike and car usage.
- Persistent challenges in land use planning, regulatory enforcement, and behavioural change continue to hinder effective implementation of sustainable mobility measures.

8. Conclusion and Future Work

8.1 Conclusion

The study concludes that an integrated framework combining conventional infrastructure investments with smart mobility innovations yields significantly improved outcomes in mitigating urban congestion. The results underscore the importance of data-driven, adaptive management in contemporary urban settings, demonstrating that AI-based forecasting and dynamic control, when implemented alongside traditional measures, can substantially reduce travel delays, emissions, and associated economic losses.

8.2 Future Research Directions

- To enhance external validity, the modelling framework should be extended to encompass a wider range of urban typologies.
- Future simulations should integrate emerging mobility trends, including real-time multimodal coordination and shared autonomous vehicle systems.
- Further research should assess the scalability and real-world implementation challenges of AI- and ITS-based solutions, with attention to equity, interoperability, and governance considerations.
- Consistent with recommendations in the literature, advanced metrics and sensor-based methodologies should be explored to enable more accurate and continuous assessment of traffic dynamics and their impacts.

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