AI for Enhancing Urban Mobility and Lowering Carbon Footprints: An In-Depth Review of Various Approaches

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RÉSUMÉ

À l'heure de l'urbanisation croissante et des préoccupations environnementales, les solutions de mobilité urbaine durable sont plus cruciales que jamais. Face à l'augmentation des villes et de leur population, les systèmes de transport traditionnels sont confrontés à des défis inédits tels que la congestion, l'inefficacité et l'augmentation des émissions de carbone. Relever ces défis complexes exige des solutions novatrices s'appuyant sur des technologies de pointe. L'approche multidisciplinaire de ce travail est un aperçue qui englobe les perspectives organisationnelle, technologique et énergétique, reconnaissant que des solutions efficaces nécessitent une compréhension approfondie des systèmes interconnectés qui régissent la mobilité urbaine. D'un point de vue organisationnel, l'intégration de l'IA et de l'IdO favorise la collaboration entre les différentes parties prenantes, notamment les particuliers, les entreprises et les entités gouvernementales. Cette collaboration est essentielle à l'élaboration de cadres et de politiques promouvant des pratiques de mobilité durable. Grâce à la collecte et à l'analyse de données en temps réel rendues possibles par la convergence de l'IA, de l'IdO et de l'AA, les villes peuvent améliorer leurs systèmes de transport public, optimiser la gestion du trafic et améliorer l'expérience des usagers.

Enfin, la mise en œuvre de technologies intelligentes peut entraîner une diminution notable des émissions de carbone d'un point de vue énergétique. Les villes peuvent s'orienter vers un avenir plus durable en stimulant le développement des énergies renouvelables, en encourageant l'utilisation des véhicules électriques et en optimisant la consommation d'énergie des systèmes de transport. Cette étude souligne l'intérêt d'une approche interdisciplinaire pour relever les défis des villes contemporaines, en mettant en lumière les synergies entre l'IA, l'IoT et l'apprentissage automatique dans le contexte de la mobilité urbaine. Nous souhaitons enrichir le débat actuel sur le développement urbain durable et stimuler des solutions novatrices pour un environnement urbain plus propre et plus efficace, en analysant en profondeur ces technologies et leurs

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implications. Afin de garantir que les progrès technologiques soutiennent les objectifs organisationnels et énergétiques, ce projet vise à sensibiliser les acteurs industriels, les législateurs et les urbanistes aux approches pratiques de la mobilité urbaine durable. Nous mettons en lumière les difficultés et les points de vue propres à chaque approche.

***Mots-clés** : IA, approche organisationnelle, gestion technologique, améliorations énergétiques, empreinte carbone, mobilité urbaine.*

ABSTRACT

In an era of growing urbanization and environmental concerns, sustainable urban mobility solutions are more crucial than ever. As cities and populations increase, traditional transportation systems encounter hitherto unseen challenges like gridlock, inefficiency, and elevated carbon emissions. Addressing these intricate issues requires creative solutions that leverage cutting-edge technologies. This study examines how artificial intelligence (AI), the internet of things (IoT), and machine learning (ML) can simultaneously reduce carbon footprints and enhance urban sustainability.

The multidisciplinary focus of this work encompasses organizational, technological, and energy perspectives, recognizing that effective solutions require a thorough understanding of the interconnected systems driving urban mobility. From an organizational standpoint, the integration of AI with IoT promotes collaboration among various stakeholders, including individuals, corporations, and governmental entities. Collaboration is key to developing frameworks and policies that promote sustainable mobility practices. Through the use of real-time data gathering and analysis enabled by the convergence of AI, IoT, and ML, cities may enhance their public transportation systems, optimize traffic management, and improve customer experience. With the use of these technologies, urban planners and transportation engineers may design more efficient networks that satisfy the needs of various populations while reducing their negative effects on the environment.

Last but not least, implementing smart technologies can result in a notable decrease in carbon emissions from an energy standpoint. Cities can move toward a more sustainable future by boosting the development of renewable energy sources, encouraging the use of electric vehicles, and optimizing energy consumption in transportation systems. This review highlights the value of an interdisciplinary approach in tackling the problems of contemporary cities by shedding light on the synergies between AI, IoT, and ML in the context of urban mobility. We intend to add to the current conversation on sustainable urban development and stimulate creative solutions for a cleaner, more effective urban environment by thoroughly analyzing these technologies and their implications. In order to ensure that technological improvements support organizational and energy-related goals, this project aims to educate industry stakeholders, legislators, and urban planners on practical approaches to sustainable urban mobility. We draw attention to the difficulties and viewpoints of each approach.

***Keywords**: AI IoT, ML, organizational management, technological management, energy upgrades, carbon footprint, urban mobility.*

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INTRODUCTION

Urban transportation systems encourage mobility, social interaction, and economic activity. They are central to modern city life. However, they also significantly contribute to environmental harm notably carbon emissions. The demand for smart, practical, and sustainable urban mobility solutions increases because cities and populations expand (Berrill, et al., 2024). Therefore, stakeholders work to improve urban mobility, reduce traffic and carbon emissions. Besides, Artificial intelligence (AI), the internet of things (IoT), and machine learning (ML) are new technologies that have revolutionary potential to improve transportation networks, reduce traffic, and lower carbon footprints. Various studies investigate the relationship between energy system upgrades and technological innovation. Looking at how electrification projects, IoT-enabled infrastructure, AI-driven traffic management, and organizational strategies can all work together to create more sustainable transportation ecosystems. Modernization of the energy system, policy alignment, and strategic management are necessary for the success of technological advancements, even though they offer strong instruments for efficiency gains. For instance, AI-enhanced traffic simulation on American urban mobility and safety (Haque, 2025; Hasan et al., 2022 ; Bawack et al., 2022)

AI-based models in conjunction with IoT sensors (can establish a connection with any service, over any network, at any time, and from any location) outperformed the other approaches tested, boosting safety metrics in a variety of urban settings and cutting average traffic delays by as much as 30%. The transformative potential of incorporating AI, IoT, and predictive analytics into urban traffic management is highlighted by this systematic review, which provides a model for more intelligent and environmentally friendly urban transportation options (Shulajkovska et al., 2024). Renugadevi et al., (2023) define Smart cities (London, Singapore, Copenhague, Shenzhen, Stockholm..) as cities connected in a number of ways, such as smart movement, smart people, smart government, smart health, and smart communication. By optimizing urban services like resource management, public safety, and transportation, AI-based models are essential for smart cities and play a key role in enhancing sustainability, efficiency, and quality of life. They use predictive analysis to improve security, manage energy grids, optimize traffic light timing, and improve public transportation by analyzing vast sensor datasets and making data-driven decisions in real time (Khalil et al., 2021 ; Aljarrah, 2024). However, governments face significant challenges in producing energy and delivering it to those in need. A lot of energy is being utilized as a result of the significant population growth, which is detrimental to both the environment and human health. As a result, having an effective method for producing and utilizing energy supplies is crucial.

This work investigates how to improve urban transportation systems, reduce traffic and lower carbon emissions in cities by utilizing IoT, machine learning (ML), and artificial intelligence. Furthermore, it gives an overview of how cities can use innovation to create smarter, cleaner, and more resilient transportation systems by combining insights from empirical research, global case studies, and technological assessments. The results underscore the necessity of integrated strategies that integrate managerial, technological, and infrastructure developments, while also highlighting the transition to low-carbon mobility's opportunities and challenges.

The current study thoroughly assesses three primary strategies: energy system upgrades, organizational management, and technology measures put in place. The paper gives a thorough explanation of how several approaches could be used to enhance urban mobility and lower carbon emissions. The importance of AI, IoT, and ML in enhancing energy systems and traffic management efficiency is highlighted.

Artificial intelligence (AI) refers to the ability of systems to simulate human intelligence to perform a variety of tasks, while machine learning (ML) is a specific method within AI that allows systems to learn from data without explicit programming. The Internet of Things (IoT) concerns the connection of physical objects to the internet to collect and exchange data, without necessarily involving intelligent analytics or machine learning. In summary, although these concepts have distinct definitions, they often interact and complement each other in modern applications.

In the end, this study seeks to educate industry stakeholders, policymakers, and urban planners on practical approaches to sustainable urban mobility, making sure that advancements in technology complement organizational and energy-related objectives. We highlight challenges and perspectives of each approach.

I. ORGANIZATIONAL MANAGEMENT

From the standpoint of organizational management, reducing carbon footprints and promoting urban mobility require strategic planning, cooperation, and sustainable practices. This approach is based on three main axes: Policy and Governance, Public-Private Partnerships and Behavioral Change and Awareness:

I.1. Policy and Governance

This section underlines the role of regulations, policies, and urban planning in shaping sustainable mobility. It involves various forms notably:

I.1.1. Public transport incentives

Alternate forms of transportation, including buses, bikes, cars, and electric vehicles can be implemented sustainable transportation strategies. Significant incentives include things like providing electric vehicle charging stations and lowering the cost of public transportation passes. Indeed, between 2018 and 2022, the total number of electric buses (e-buses) increased from roughly 1,650 to over 9,500, and their sales share increased from 2.5% to 10% (EAFO, 2022). Comparative studies show that electric buses are better for the environment than diesel or compressed natural gas vehicles, particularly because they have no exhaust emissions (Dulce et al.,2024; Zheng et al., 2024). Then, electric buses drastically cut carbon emissions generated by public transport (Gustafsson et al,; 2021; Andriollo & Tortella, 2015). For example, cities like Shenzhen, China, (Rodrigues & Seixas, 2022), Padova, Italy (Andriollo & Tortella, 2015) and Stockholm (Giagnorio et al., 2024) have shown the considerable environmental benefits made possible by the widespread use of electric buses, achieving notable decreases in noise pollution and emissions. A variety of incentives and obstacles affect the uptake of electric cars (EVs). Although EVs have advantages including lower prices and emissions, they are having trouble being widely accepted. EV adoption has been significantly accelerated by government subsidies, tax credits, and EV charging infrastructure, which have increased their convenience and financial appeal. Broader adoption has been hampered, though, by obstacles like high upfront prices, a short driving range, inadequate charging infrastructure, and consumer worries about battery availability and life. Through an analysis, Javadnejad et al., (2024) offer a new method for summarizing the variables affecting EV development in the US by taking into account both incentives and barriers. The study helps stakeholders and policymakers creating policies and programs that effectively encourage EV adoption and contribute to a cleaner and more sustainable future, this research offers a thorough understanding of the incentives and obstacles to EV development in the US.

Then, a research uses a mixed logit model and a latent class choice model to examine individual responses to incentives and pinpoint important variables that affect their efficacy. In order to analyze people in each latent class and uncover their varied preferences for public transportation in various places, the data used in this study came from a mobile navigation application that covered 34 cities in China. Classified into three main latent classes, Liu et al., (2025)'s findings show significant individual differences in response to incentives: Class 1 individuals show minimal influence from incentives; Class 2 individuals show moderate responsiveness, particularly to food and shopping coupons; and Class 3 individuals, whose decision-making is significantly influenced by gender, education level, and preferred mode of transportation, exhibit a high degree of responsiveness to incentives. This study underlines the role of policymakers in creating more specialized, efficient incentive programs to promote the use of public transportation.

In congested urban train systems, overcrowding problems can be successfully reduced via incentive-based public transport demand management (PTDM). Designing, implementing, and updating PTDM tactics can be guided by examining how passengers behave in response to the incentive. Although a number of studies documented how passengers reacted to fare incentives, they concentrated on the immediate behavioral reactions of passengers. Few researches examine the longitudinal behavioral responses of passengers for various adopter types, which is crucial for evaluating and modifying policies. This study uses 18 months of smartcard data from Hong Kong's public transportation system to investigate and predict passengers' longitudinal behavior response to a pre-peak fee discount incentive. The findings of the discrete choice model demonstrate how various factors have varying effects on various adopter types and their time change values. Flexibility in departure time, anticipated cost savings, necessary departure time adjustments, and work locations are important considerations shared by adopters. (Wang et al., 2025). Yan et al. 2025 use financial tactics, such as incentives and fines, have been recognized as a successful way to control traffic demand and lessen congestion-related problems by encouraging people to take public transportation. Personalized travel incentives are typically more socially acceptable than financial penalties like road tolls. Authors used huge amount of quasi-experimental data from a popular public transit incentive program that is included in one of the biggest navigation apps in China, this study aims to determine the factors that influence people to switch to public transportation. Users' sociodemographic information and their local and long-distance travel habits are included in this data. To analyze and forecast changes in consumers' use of public transportation, two models are used: a binary Logit model and an adaptive stacking extreme gradient boosting (AS-XGB) model. One of the important determinants, in addition to gender, work type, and preferred method of transportation, is the incentive reward category. However, authors find that the impact of factors like preferred method of transportation, automobile ownership status, and educational attainment differs significantly depending on the level of development of the city. Both the user's wealth and educational attainment have a major influence on the effectiveness of the incentive for intercity travel, whether or not the user has a car.

I.1.2. Congestion pricing

The concept and four primary applications of Rate control protocol (RCP) are introduced by Zhou et al., 2025. In this study, author find that RCP will have an immediate impact on locals' travel habits and, over time, alter their choices about where to go. This will result in new demands for travel and other ways to get there, which will have an impact on the transportation system and urban spatial patterns once more. The use of cordon, RCP will have an immediate impact on locals' travel habits and, over time, alter their choices about where to go. This will result in new demands for travel and other ways to get there, which will have an impact on the transportation system and urban spatial patterns once more. The population of city centers is affected by agglomeration when cordon charges are implemented. Additionally, cordon costs have a dispersive effect on jobs and a major detrimental effect on businesses in the toll region. When paired with suitable shared autonomous vehicle solutions, RCP can enhance regional accessibility and transportation efficiency at the same time.

In addition, Isaksen & Johansen (2025) investigate if congestion pricing that includes exemptions for electric vehicles (EVs) speeds up this transition by promoting the use of greener automobiles. For that, authors utilize a triple-differences methodology that takes advantage of household-level differences in policy exposure across cities and work commutes in conjunction with administrative data on car ownership to determine causal effects. They discover that EV adoption is greatly increased by higher rush-hour fees for conventional vehicles, mostly through replacement rather than fleet expansion. Responses, however, differ according to socioeconomic factors; households with greater incomes and better levels of education are more likely to use EVs. The study records behavioral changes beyond car ownership, such as moving to avoid tolls, rerouting around the cordon, and rearranging travel schedules. In general, congestion charging enhanced air quality and decreased traffic loads. This research provides guidance for creating just and practical transportation regulations.

Pathan & Landge (2025) investigate whether congestion pricing is acceptable in Srinagar, India, in light of the city's expanding urbanization, rising private vehicle ownership, and deteriorating public transit system. The study uses ordered probit and discrete choice models to determine the determinants impacting congestion pricing adoption through a survey administered at important places of employment, tourist attractions, and retail centers. The results show that a higher willingness to accept congestion pricing is positively connected with education, income, and other socioeconomic. According to the findings, congestion pricing may be a useful instrument for reducing traffic as long as road safety and public transportation systems are improved. Based on these results, the report suggests utilizing congestion pricing money to improve public transportation quality and accessibility as well as urban road safety. These understandings are essential for creating congestion pricing policies that work, meet the particular transportation requirements of Indian cities, and guarantee fair results for all commuters.

I.1.3. Low-emission zones

One of the biggest problems facing cities is air pollution, which causes 7 million deaths annually worldwide (UN, 2023). Low Emission Zones, which have been implemented in cities to limit the number of trips made by extremely polluting cars, are one of the many policies that have been implemented to minimize the emissions of dangerous pollutants. They have been a popular method for enhancing air quality throughout Europe in recent decades (Poulhès et al., 2025). London is the first city in the world to establish an Ultra-low Emission Zone. Broster & Terzano (2025) use two reliable regression models for two research concerns about the important indicators of pollutant concentrations and long-term health benefits after low emission zones implementations. According to the findings, there is statistically strong proof that low emission zones reduce pollution, which has long-term positive effects on health, and the significance of reducing dangerous pollutants, which policymakers in other places should also take into account.

Park & Lim (2025) show how Seoul's ULEZ policy affected the concentrations of the five main air pollutants. In 2019, Seoul, adopted an ultra-low emission regulation. By preventing the admission of cars registered nationwide that do not meet a certain emission threshold, such as those powered by diesel, gasoline, or LPG, into Seoul's ULEZ, the policy seeks to improve the quality of the air. The analysis uses the Difference-in-Differences (DD) technique. The results show that PM2.5 concentrations increased by 9.8% as a result of Seoul's ULEZ policy. On the other hand, the policy reduced the concentrations of PM10, NO2, CO, and SO2 by 12.0%, 17.3%, 5.9%, and 10.8%, respectively, but had no statistically significant effect on O3. These empirical findings imply that in order to mitigate the unanticipated increase in PM2.5 concentration, the ULEZ may need to implement additional measures, broaden its coverage, or include stricter emission standards. Poulhès et al., (2025) work on identifying the inhabitants of the Paris region (France) who are most harmed by the ownership of non-compliant automobiles and those who are least affected by reductions in air pollution. The methodological approach first assesses the spatiotemporal exposure of surveyed persons, taking into account their activities and modes of transportation, by combining data from the Transport global survey with data on spatiotemporal NO2 concentration levels. Therefore, authors use logistic regression models and findings show that limitations on non-compliant vehicles have the greatest impact on the poorest citizens, both in terms of exposure and ownership, leading to a double standard of inequality. In a more ambitious scenario, this discrepancy is less noticeable.

I.2. Public-Private Partnerships

I.2.1. Case studies

Local governments encourage Cooperation by Developing integrated mobility solutions and collaborating with communities and other organizations. Innovative initiatives like shared mobility services (such as bike and ride sharing) can result from public-private partnerships. Many case studies show the successful collaboration between government and communities to improve mobility systems: Bogotá, Colombia was facing extreme congestion and increasing air pollution. The local government collaborated with private companies to develop TransMilenio, a bus rapid transit (BRT) system. Therefore, TransMilenio reduced travel times, reduced CO_2 emissions, and improved air quality. It now carries millions of passengers every day (Gilbert, 2008). Then, Paris also sought to promote eco-friendly travel and reduce traffic congestion. The city collaborated with private companies to launch Vélib', a self-service bicycle system. Vélib' encouraged cycling, reduced greenhouse gas emissions, and improved urban mobility. It became a model for other cities. California sought to reduce its reliance on cars and planes for long-distance travel. The state government collaborated with private companies to develop a high-speed rail network. Although still under construction, this project aims to reduce carbon emissions and provide a sustainable alternative to traditional transportation. Next, Singapore sought to optimize its transportation systems and reduce its carbon footprint. The government collaborated with technology companies to develop smart mobility solutions, such as real-time traffic management systems. Singapore reduced congestion, improved the efficiency of public transportation, and reduced CO_2 emissions. London sought to encourage cycling and reduce traffic congestion. The city collaborated with private companies to create safe and well-connected "cycle superhighways." These infrastructures increased cycling, reduced emissions, and improved public health. For the Niigerian case Adebajo & Johnson (2025), through a report, recommend integrating sustainable transportation options, increasing PPP investments in underprivileged areas, fortifying regulatory frameworks, and encouraging public participation. Authors highlight that Nigeria can guarantee that PPP-driven transportation projects support sustainable urban mobility and long-term economic and social development by putting these principles into practice. Wen et al. 2025 assess the effectiveness of a collaborative initiative named "New Energy Vehicle to Countryside" that includes a number of electric Vehicule producers, local governments, and an NGO. Authors advise governments to employ collaborative policy tools more frequently, especially during emergencies like the epidemic, while carefully analyzing the policy arena, sectoral decision-making, and operational procedures. When using collaborative policy instruments to support a specific emerging industry, like Electric vehicule, authors recommend first implementing demonstration programs in regions with better industrial foundations, market potential, and local policy support to boost program success. In Rotterdam, In the context of the local climate agreement, the politically supported but informal governance process mobilized public-private-civil networks of actors to co-create a transition strategy based on zero-emissions, social, and shared mobility in 2030, with the goal of all remaining vehicles being shared and free from tailpipe emissions. It pushed local policy to further encourage walking, bicycling, sharing, and public transportation, and it hastened a variety of discussions, activities, and improvements in the city (Loorbach et al., 2021)

I.3. Behavioral Change and Awareness

Organizations can encourage urban mobility by removing the need for frequent travel, flexible work arrangements like remote work, hybrid models, or flexible hours can lower carbon emissions. By funding eco-friendly infrastructure such as bike lanes, pedestrian-friendly sidewalks, green areas, carpooling an cycling. The objective is to emphasize how crucial it is to encourage environmentally friendly travel practices. The usage of non-motorized alternatives is obviously influenced by specific sociodemographic traits, and people who utilize public transportation or active travel report higher levels of well-being than those who drive (Boichuk, 2025).

I.3.1. Carpooling

Boichuk (2025) uses ordinary least squares (OLS) models estimated from the Multinational Time Use Study (MTUS) for the following countries: Bulgaria, Canada, Spain, Finland, France, Hungary, Italy, South Korea, the United Kingdom, and the United States, this study examines the behavior of carpooling for commuting. Since less than 25% of the time spent driving to and from work is spent with other people, the results show that carpooling is not a common practice among employees. Regarding the contribution that people's sociodemographic traits play, data suggests that there may be a consistent, cross-country association between carpooling participation and age, gender, education, native origin, and household composition. In addition, Through microscopic traffic simulation modeling and microscopic vehicle exhaust emissions estimation, Tomás et al., 2021 sought to produce an analysis of the road traffic and emission implications of implementing carpooling with social distancing measures in three university campus networks. The findings show that carpooling, which allows groups of up to three people to safely commute from their neighborhood to the university campus, can significantly improve road traffic performance (average speed increased by 7% and travel time reduced by 8%) and reduce pollutant emissions within the network (carbon dioxide and nitrogen oxides can be reduced by 5% and 7%, respectively). However, Bruck et al, (2017) incorporate the heuristic algorithms to offer carpooling options to users. According to experimental studies, carpooling has a significant potential to reduce CO2 emissions in both real-world and newly created scenarios.

Arbeláez (2024), adds Travel behavior, the design of shared mobility modes, the implementation of such schemes, and the local context are as factors that affect changes in the environmental implications of passenger transportation from shared mobility. Arbeláez ‘s analysis can help local governments and shared mobility organizations better understand these characteristics and take into account the life-cycle phase where the biggest impacts occur. In a French context, Olave-Cruz et al. 2025 examine how the adoption of carpooling is influenced by policies that affect the financial cost of travel. Authors demonstrate that raising monetary trip expenses through carbon pricing increases carpooling supply and demand. Additionally, they discover that new users are especially vulnerable to changes in the cost of monetary trips. Therefore, they investigate the impact of encouraging drivers to switch to passenger status in addition to this strategy.

I.3.2. Cycling

With the main objective of lowering the usage of private vehicles that burn fossil fuels, cycling has been promoted as an alternative to other modes of transportation in cities in recent years. In early adopter cities like Amsterdam and Copenhagen, which are enjoying the fruits of their labor, more than 40% of trips are now made by bicycle (Pucher, Dill et al., 2010). By integrating bicycle infrastructure into urban planning, cities can lessen their reliance on motor vehicles, which lowers pollutants and improves public health.

Gonzalo-Orden et al., (2014) discuss some of the advantages and benefits of cycling as well as some factors that affect its use. In order to determine how the more than 70 kilometers of bicycle networks in various cities in the Castile and Leon region of Spain may impact bicycle use, the study looks at the barrier elements, particularly the structural barrier factors. Resuls show That the total length of the bicycle network is less important than the number of destinations and completed itineraries that can be reached safely and effectively. The Netherlands deserves special attention because cycling rates are so high across the country, not just in one city (Fishman et al. 2015). The rest of the world can learn a lot from the Dutch experience. In Utrecht region, Knap et al., (2023) reaffirming that cycling can be a useful way to lessen transportation disparities. Cities aiming to become X-minute cities can be evaluated using the created metric, which can also be used to prioritize the development of neighborhoods, define quantitative goals, and examine planning scenarios.

In summary, technology and organizational management work together to transform urban mobility and lower carbon emissions. When developing urban transportation systems, an integrated approach encourages creativity, effectiveness, and sustainability.

II. TECHNOLOGICAL MANAGEMENT

We Discuss the role of IoT, AI, and big data in optimizing urban transportation system. Indeed, the goal of the Internet of Things is to connect physical devices, such as sensors, and help them communicate over the internet. Artificial intelligence aims to help machines develop human-like intelligence so they can better communicate with both humans and machines. However, ML is an application of AI that allows machines to extract knowledge from data and learn from it autonomously.

II.1. AI-Driven Traffic Management

The use of AI algorithms to evaluate real-time traffic data and forecast congestion patterns is one of the many strategies that form the foundation of AI traffic management. Next, puting in place adaptive traffic signal systems that modify timings in response to traffic patterns. In order to cut down on travel time and fuel consumption, AI-powered route optimization tools for logistics and public transportation should be implemented. Table 1 summarizes authors findings on AI- Driven Traffic management :

Table 1. AI-Driven Traffic Management

Authors	Models	Findings or study goal
Ponnusam et al., 2024; Ma et al., 2009; Tahir & Rasool (2025)	Emphasize how AI algorithms are used in vehicle-infrastructure integration (VII) systems.	Reducing congestion, improving safety
Laanaou et al., 2024; Mohanty et al., 2025	AI algorithm real time traffic	Managing high precision and low latency to speed up data processing is one of the many challenges vehicular ad hoc networks (VANETs) confront.
Du et al., 2025	Examination of factors such as the probability density segmentation principle, road network architecture,	Increases traffic efficiency by about 10.95% by altering vehicle trajectories in comparison to the

	congestion index, and MVPP-ACI-AI	traditional A* algorithm.
Kandiri et al., 2025; Mirindi et al., 2025	Creates an autonomous agent by combining data observations and simulation.	Making the best choices for traffic control in real time. The agent can reduce the average travel time by up to 55% and the average waiting time by up to 69% in a crowded situation. The significant improvement in average travel times at the studied M50 crossroads shows how autonomous agents can enhance real-time optimal traffic management.
Kadkhodayi et al., 2023	Artificial neural networks accurately predict urban traffic flow, and the artificial bee colony method optimizes signal timings in a distributed multi-agent architecture using meta-heuristic AI techniques.	To address problems with path routing in urban traffic

Source Authors's work

Findings show that most studies use AI algorithm for identifying real time traffic in order to find the average travel time.

II.2. IoT-Enabled smart infrastructure

The objective is to improve urban mobility system management and monitoring. To gather information on usage, occupancy, and environmental conditions, install Internet of Things (IoT) sensors in parking lots, roadways, and public transportation. Reduce the amount of time spent looking for parking spaces, cut emissions, and use IoT to control smart parking systems. Real-time monitoring of emissions and air quality is necessary to pinpoint pollution hotspots and implement remedial measures. Table 2 summarizes the role of IoT on smart infrastructure:

Table 2. The role of IoT on smart infrastructure

Authors	Models	Findings
Vadivel et al., (2023); Bajaj et al., 2020; Rao et al., 2022; Majumdar et al., 2021; Ahmed et al., (2024); Majumdar et al., 2021	IoT-connected wireless sensor networks ; Actor-Network Theory..	Cities may be able to improve mobility, lessen traffic, and create sustainable cities with the use of real-time data.
Sharma & Garg (2023); Rajkumar, Y., & Santhosh Kumar, S. V. N. (2024).; Jagatheesaperumal et al., (2024). Lu & Wang (2024)	Survey, ultrasonic sensors,	Safety in intelligent transportation

Source Authors's work

Findings on table 2 show that IoT sensors play a crucial role in urban traffic management and congestion reduction. They collect real-time data on traffic flow.

II.3. Machine Learning for Predictive Maintenance

The objective of ML for predictive maintenance is, first, to increase transportation infrastructure efficiency and decrease downtime. Then predicting equipment failures in public transportation systems (such as buses and trains) and plan maintenance in advance by using machine learning models (Table 3) and finally, examining past data to find trends and improve road, bridge, and other infrastructure maintenance plans.

Table 3. ML & predictive maintenance

Authors	Models	Findings or study goal
Alqasi et al., 2024; Chen, G., & wan Zhang, J. (2024).	AI-based predictive maintenance model	detects irregularities and forecasts failure patterns by analyzing real-time data from embedded sensors in urban infrastructure. According to the findings, the predictive maintenance model can prevent almost 92% of unplanned failures, improve reaction times, and save maintenance expenditures by 30%. These results highlight how AI-driven strategies can minimize unforeseen interruptions, maximize resource allocation, and prolong the lifespan of infrastructure, ultimately resulting in safer and more sustainable urban transportation networks.
Dunka et al., 2022; Sanusi (2025).	In order to anticipate possible problems and plan maintenance tasks ahead of time, machine learning algorithms examine data from vehicle sensors, past maintenance records, and usage trends.	Lower operating expenses, improve vehicle performance, and increase delivery efficiency
Mallouk et al., 2021; Kalathas, & Papoutsidakis (2021).; Shaikh et al., 2024; Rziki et al., (2025).	Using a machine learning method, multiple regression algorithms are compared to create a prediction model based on supervised learning.	The model was used to anticipate the remaining useable mileage of truck tires for the transportation of hazardous materials, the Greek railway, and the metro system (which reduces delays and reliability).

Source Authors's work

In summary, ML predictive maintenance detects irregularities and forecasts failure patterns by analyzing real-time data, anticipate the remaining useable mileage of truck tires.

We focus on AI, ML and IoT, including the crucial role of the Platforms for Shared Mobility in encouraging resource efficiency and lessen the number of cars on the road, by creating AI-driven carpooling and ride-sharing networks that pair users with comparable routes. However, various studies recommend integrating AI with IoT and ML to construct responsive urban mobility systems (Hossain et al., 2024). Then, by using of e-scooters and bike-sharing as micro-mobility options for short-distance transportation. And optimizing fleet management and guarantee effective use of shared vehicles by utilizing data analytics. As an illustration, businesses such as Uber and Lyft employ AI to maximize ride-sharing and minimize emissions.

Also, the role of Autonomous Automobiles (AVs), by increasing urban mobility's efficiency and safety. Indeed, AVs Create and implement driverless cars that minimize human error and maximize fuel economy. To facilitate smooth communication between automobiles and traffic systems, integrate AVs with smart city infrastructure. Utilize autonomous vehicles (AVs) for last-mile delivery to cut down on emissions and traffic in cities. As an illustration, businesses such as Tesla and Waymo are spearheading the advancement of autonomous car technology.

Then, Transportation Electrification switch to vehicles with zero emissions. Indeed, the strategy adopted is encouraging the use of electric vehicles (EVs) by providing incentives and constructing charging infrastructure, managing EV charging stations and maximize energy use with IoT. Create battery-swapping technologies to increase convenience and shorten charging times. As an illustration, to cut carbon emissions, cities like Oslo have made significant investments in EV infrastructure. The following section highlights the role of those technologies in upgrading energy system.

III. ENERGY SYSTEM UPGRADES

Transportation Electrification mentioned above, is one of the energy system approaches. It cuts emissions, switches to electric vehicles (EVs) from vehicles that run on fossil fuels through Increasing EV Charging Infrastructure: Set up fast-charging hubs and other public and private EV charging stations throughout cities. Then through encouraging EV Adoption: Provide tax breaks, subsidies, and other incentives to entice people and companies to convert to electric vehicles. And Fleet Electrification: Convert logistics vehicles and public transportation fleets (such as buses and taxis) to electric models. For instance, EV infrastructure and incentives have been successfully introduced in cities like Oslo and Amsterdam. Indeed, authors study various axes to highlight energy systems upgrades:

III.1. Integration of Renewable Energy

Three approaches are highlighted by authors to clean, renewable energy sources to power transportation systems.

First, Solar and Wind Energy: Set up wind turbines and solar panels to produce electricity for public transportation and EV charging stations. Simankov et al., (2024) focus on the methodology of applying contemporary approaches to the evaluation of energy output from renewable energy sources based on artificial intelligence technologies, data processing techniques, and control process optimization for energy system operation with renewable energy source integration. Authors involve a generic methodology based on artificial intelligence technology for assessing renewable energy sources like solar and wind energy is what makes the work relevant. Razak et al., (2025) show that hybrid models are being used more frequently, that interpretable and physically grounded approaches are becoming more popular, and that AI methodologies are consistently underreported in the literature.

Then, energy Storage. Indeed, to store renewable energy and guarantee a steady supply of power for transportation requirements, use battery storage systems. For instance, the smart household energy management system (SHEMS), which aims to maximize residential energy use, making advantage of the Internet of Things (IoT), SHEMS provides households with a flexible architectural framework to control their energy use through real-time energy monitoring and management (Abbasi et al., 2024; Ojo et al., 2025)

Finally, microgrids or smart Grids create regional energy networks fueled by renewable sources to assist with urban transportation systems. Smart grid technologies are implemented to balance energy demand and supply, especially during peak charging times. Vehicle-to-Grid (V2G) Technology enable EVs to feed excess energy back into the grid, creating a two-way energy flow. For instance, Pilot projects in Denmark and the UK are testing V2G technology to enhance grid stability. IoT and ML provide a powerful tool for effectively and securely handling the vast amounts of historical data and the real-time data stream. They also make microgrids easier to operate (Negi et al., 2025; Tasmant et al., 2025; Dui et al., 2025; Lei et al., 2024).

III.2. Decentralized Energy Systems

The goal of decentralized energy systems is to improve energy resiliency and lessen dependency on centralized power plants. Decentralized Energy Systems are based on three main axes. First, local Energy Generation by promoting the use of small-scale wind turbines and rooftop solar panels for local energy production. Then, community Energy Projects by create renewable energy projects that are owned by the community to power transportation networks. Finally, Energy Sharing. Indeed, EV owners and other users can share energy among themselves by using blockchain technology. Collaborative Edge Artificial Intelligence can improve decentralized energy systems (Paula et al., 2025; Abd Algani et al., 2024; Nikbakht et al., 2024).

III.3. Carbon Capture and Offsetting

This technology reduces emissions from partially electrified transportation networks. It is based on Carbon Capture technology by making an investment in technology that absorb CO2 emissions from automobiles. Carbon Offsetting Programs by Collaborating with groups to finance carbon credits, renewable energy initiatives, or reforestation in order to offset emissions. Low-Carbon Fuels by Encouraging the substitution of synthetic fuels, hydrogen, and biofuels for fossil fuels (Chen et al., 2024; Calel at al., 2025)

IV. DISCUSSION

There are many chances to increase productivity and lower carbon footprints when artificial intelligence (AI), the Internet of Things (IoT), and machine learning (ML) are integrated into urban mobility systems. These developments, however, present unique viewpoints and challenges in three important areas : Organization, technology and energy.

Organizational Challenges : The division of stakeholders in urban mobility is one of the main organizational challenges. With their own objectives, priorities, and operational frameworks, cities frequently consist of a number of government agencies, private businesses, and community organizations. Silos that obstruct cooperation and the creation of coherent strategies may result from this fragmentation (Orji, 2024). Furthermore, it can be challenging to implement integrated solutions because these entities frequently lack standardized protocols and data-sharing agreements. Then, organizational resistance to change can also be a major obstacle. The adoption of cutting-edge technologies and cooperative strategies that are necessary for sustainable urban mobility may be slowed down by established procedures and administrative frameworks. However, building a collaborative culture among stakeholders is essential to overcoming these obstacles. This can be accomplished through collaborative projects, public-private partnerships, and goal-aligning community engagement activities. Establishing cross-sectoral governance structures and creating standardized frameworks for data sharing will also be essential to advancing a cohesive strategy for urban mobility.

Besides, one major obstacle to successful implementation is cost. Indeed, the success of such initiatives is largely dependent on financial management, resource allocation, and budgeting. Furthermore, significant financial resources are required for infrastructure upgrades, new technology acquisition, and system integration into preexisting frameworks in order to deploy AI, IoT, and ML systems. The upfront expenses can be intimidating for many municipalities, especially those with tight budgets. The requirement for continuous maintenance and support, which can put additional strain on already scarce resources, frequently makes this financial burden worse. Additionally, these technologies intricacy may result in unanticipated costs during the implementation stage. Cities may have to pay more than they anticipated for staff training, process adaptation, and overseeing the switch from conventional to smart technologies. Organizations may find it difficult to defend investments in these cutting-edge solutions if they do not have a clear grasp of the total cost of ownership.

An additional layer of cost challenges is brought about by the organization's emphasis on funding and budget allocation. Urban mobility initiatives frequently face competition from other urgent municipal needs like housing, education, and public safety for scarce financial resources. It can be challenging to get funding for AI, IoT, and ML projects, especially when decision-makers favor initiatives that have observable, immediate benefits. Investment may also be hampered by the absence of well-established funding models for creative urban mobility solutions. The long-term advantages of improved mobility systems, like less traffic, better air quality, and higher economic productivity, might not be sufficiently captured by traditional funding methods. Because of this, organizations might find it difficult to promote budgetary allocations that take into account the wider societal benefits of these technologies (Luz & Iseal, 2025; Orji, 2024)

Challenges from a technological perspective : The quick development of AI, IoT, and ML offers both possibilities and difficulties from a technological standpoint. The incorporation of these technologies into the current infrastructure is a major obstacle. Many urban settings have outdated systems that might not work with modern technology, requiring large expenditures for adaptations and upgrades. Then, concerns about data security and privacy present serious obstacles as well. The need for large-scale data collection for AI and IoT applications begs the question of how to safeguard private data and guarantee its ethical use. Additionally, relying too much on technology can lead to vulnerabilities because transportation networks may be disrupted by system failures or cyberattacks. However, in order to overcome these obstacles, cities need to give top priority to creating reliable, compatible systems that can easily incorporate new technologies with their current infrastructure. To protect user data and uphold public confidence, investments in data governance frameworks and cybersecurity measures will be crucial. Furthermore, continuing research and development should concentrate on developing adaptive technologies that can change to meet the demands of urban mobility.

Energy perspective difficulties: The energy perspective has its own set of difficulties, mostly associated with the switch from fossil fuels to renewable energy sources. Even though EVs and other environmentally friendly modes of transportation can drastically cut carbon emissions, many cities still lack adequate energy supply and charging infrastructure. The broad adoption of greener transportation technologies may be hampered by this disparity. Furthermore, if not adequately managed, the energy requirements of AI and IoT systems themselves may increase carbon footprints. The environmental advantages of improved mobility solutions may be outweighed by the energy usage of data centers and smart devices. However, cities must make investments in developing renewable energy infrastructure, such as EV charging stations for solar, wind, or other sustainable energy sources, in order to promote the energy perspective. It will also be crucial to promote the adoption of energy-efficient practices and technologies in transportation networks. By offering incentives for the adoption of clean energy solutions and funding studies into energy-efficient technologies that enhance AI and IoT applications, policymakers can play a big part.

CONCLUSION

In conclusion, despite the enormous potential for improving urban mobility and lowering carbon footprints through the integration of AI, IoT, and ML, organizational, technological, and energy-related issues must be addressed. Cities can create a more effective, just, and ecologically friendly urban mobility environment by encouraging stakeholder collaboration, making investments in flexible technologies, and giving priority to sustainable energy solutions. In the pursuit of sustainable urban development, these initiatives' interdisciplinary focus will be crucial to breaking down obstacles and maximizing the potential of creative solutions.

The integration of AI, IoT, and ML to improve urban mobility presents also a number of cost challenges that need to be carefully considered from an organizational standpoint. Cities can overcome these obstacles and unleash the revolutionary potential of smart technologies by addressing the costs of initial investments, obtaining funding, and proving economic viability. The shift to sustainable urban mobility will be facilitated by a cooperative, strategic approach that highlights the long-term advantages of these innovations. It will also increase the general resilience and effectiveness of urban environments.

This work can participate to Strategic direction by providing decision-makers with evidence-based strategic recommendations for integrating AI, ML and IoT into urban development plans and environmental policies. Then, it encourages decision-makers to establish partnerships between the public sector, the private sector and academic institutions to foster innovation and knowledge sharing.

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