ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

INTEGRATING ARTIFICIAL INTELLIGENCE WITH ELECTRIC VEHICLE SYSTEMS FOR INTELLIGENT TRANSPORTATION AND SUSTAINABLE URBAN MOBILITY

Mehak Goyal

Research Scholar, Department of Commerce and Management, RIMT University, Mandi Gobindgarh

Vishal Vinayak

Assistant Professor, Department of Commerce and Management, RIMT University, Mandi Gobindgarh

Yashmin Sofat

Assistant Professor, Department of Commerce, A.S College, Khanna

ABSTRACT

Electric vehicle (EV) adoption is accelerating, necessitating an intelligent support system for sustainable urban travel. Building intelligent transportation systems (ITS), improving traffic management, and improving EV performance all heavily rely on artificial intelligence (AI). With 200 respondents, the Ludhiana district serves as the main data source for this study, which investigates the incorporation of AI technology in EV systems. The study assesses user experiences, obstacles encountered, adoption of AI features, and the general effect of AI on environmentally friendly transportation. User satisfaction and AI accessibility (such smart navigation, predictive maintenance, and battery range optimization) are significantly correlated, according to statistical study that includes regression modeling and descriptive statistics. The findings showed that about 70% of Ludhiana EV users cited the absence of AI-driven smart charging infrastructure, while 60% of them embraced AI-based smart navigation, indicating great technology acceptance. Future market potential is shown by the fact that more than 65% of respondents indicated interest in sophisticated AI services. AI characteristics and user pleasure were shown to be strongly positively correlated, according to regression results (R2 = 0.581). Real-time traffic predictions, however, were deemed untrustworthy by 55% of users, indicating the necessity for the creation of localized AI models. The paper concludes with recommendations for strategic AI integration to achieve sustainable and intelligent urban mobility in Ludhiana district.

Keywords: Artificial Intelligence, Electric Vehicles, Intelligent Transportation Systems, Sustainable Mobility, Ludhiana, Smart Charging, Urban Transport

1. INTRODUCTION

The growing population centers have made the need for green means of transport more pronounced than before. While AIEVs have the potential to cut down carbon footprints, their application makes them more futuristic, since their power usage, route management, and traffic control features are enhanced by AI (Sharma & Singh, 2023). Because of becoming an industrial hub of Punjab, Ludhiana is facing a lot of emerging problems like traffic jams, a lot pollution, and infrastructure imbalance. Developing AI powered EVs for use in Ludhiana is vital for construction of a smart transport system, reduction of energy use, and enhancement of mobility in the city.

Studies have reported that we see great results from AI in the area of predictive battery management (Wang et al., 2022), dynamic traffic rerouting (Gupta and Tiwari, 2020) and smart grid integration (Chen et al., 2020) which have in turn improved the performance and adoption of EVs in large metro cities. But we see that there is a gap in research which looks at mid-sized cities like Ludhiana. This study we present has tried to fill in that gap by way of a primary survey of 200 EV users in Ludhiana district.

2. REVIEW OF LITERATURE

Ahmed et al. (2021) discussed the role that artificial intelligence (AI) plays in mass adoption of electric cars (EV). The primary goal of this work is to discuss how AI helps to overcome the
disadvantages preventing the adoption of EVs by dwelling on the use of AI in improving EVs, charging infrastructure, and incorporating EV along with smart grids to make delivery of mass adoption. An extensive literature review was done comprising of various existing literature, such as company reports, case studies and scholarly publications. This study showed that it is possible to overcome existing barriers to full adoption using several opportunities making AI work in various aspects of EV technology and infrastructure. AI enables trouble free plug into smart grids, smart charging infrastructure and better batteries performance. Despite this, some problems remain such as the need to have structures in place, bandwidth, extensions, computing limitations and data availability. To demonstrate to the full extent the promise of AI in promoting the future research areas to focus on EV adoption will be the development of scalable AI models and strengthening by giving data sharing systems and promoting interdisciplinary collaboration.

Gupta and Tiwari (2021) assess the performance of AI dynamic traffic rerouting to support better urban mobility through eliminating congestion and increasing efficiency in personal and freight travel. The study has limited its field of study to the implementation of artificial intelligence in terms of traffic in real-time Urban-based management. With simulated datasets and models of urban traffic models acting in the typical congestion pattern, the researchers used a multi-agent system and reinforcement learning algorithms to evaluate the adaptability of AI, dynamically varying vehicle routes an appropriate response to real-time situations. The methodology entailed designing and testing an AI on simulations driven rerouting framework based on traffic data and scenarios of the congestion. The results showed great improvement as there was a decrease in the average travel time by 25 % and idling time by 30%, emphasizing the use of AI in terms of controlling traffic flows. The researchers were able to determine that rerouting driven by AI presents a good opportunity, urban traffic optimization solution and advised them to implement it, particularly in the fast-developing cities, such as Ludhiana.

Arévalo et al. (2024) conducted a systematic review of the current integration of artificial intelligence (AI) into electric vehicle (EV) energy management systems (EMSs). Reviewing recent advancements in AI techniques, such as AI in machine learning, deep learning, and genetic algorithms, as well as the evolution of EVs, range, performance, and energy efficiency is the main purpose of study. Only secondary sources were used in the data collection process, which was based on the meta-analyses (PRISMA) methodology of a large body of literature in 46 highly relevant articles. The results of the study demonstrate the many advantages of giving EV EMSs AI capabilities (such as improved fault diagnostics, improved battery performance, ideal energy management, and improved integration with renewable energy sources). Interoperability problems are among the other difficulties that need to be resolved as well as threats to cybersecurity and the necessity of infrastructure investment. Future research should concentrate on creating cutting-edge AI that can adjust to various driving situations, enhancing cybersecurity protocols and investigating optimisation techniques. It was determined that there should be a greater emphasis on interdisciplinary cooperation between the academic community and the business sector for such solutions to be genuine and applied to practice environments in a way that is both sustainable and effective.

Yekollu et al. (2024) evaluated the systems of integrating the Artificial Intelligence (AI) technologies into Electric Vehicles (EVs) so that EVs could demonstrate better performance, efficiency and adaptability. The primary problem that this paper is going to explore is the way that AI can solve current issues with EV technology and help to develop smart transportation systems. This information has been gathered through extensive research of the available literature, technological changes, and the emerging practices in regards to incorporating AI in EVs. Smart mobility has a lot of potentials that can be enhanced by using AI technology to digitize EVs. This paper has pointed out that AI can lead to more self-governing, reliable and efficient EV structures. Nevertheless, it is necessary to overcome the issues associated with it to provide the successful integration of AI to EVs. The conclusion of the research states that an active research and development as well as interdisciplinary collaboration would be needed to reach the potential of AI-enhanced EV technologies to the fullest.

3. RESEARCH METHODOLOGY

3.1 NEED AND SIGNIFICANCE OF THE STUDY

- The way to eliminate urban air pollution and reliance on fossil energy is Electric Vehicles, but their effects can be substantially increased with the help of incorporation in Artificial Intelligence (AI) technologies.
- AI enhances EV systems through features such as predictive battery management, autonomous navigation, smart charging, and traffic flow optimization, all of which are essential for achieving intelligent and sustainable transportation systems.
- In India, particularly in Tier-2 cities like Ludhiana, there is a lack of region-specific research on the public awareness, acceptance, and infrastructural readiness for adopting AI-integrated EV systems.
- Ludhiana, being an industrial hub with rising vehicular density, represents an ideal case to study urban transportation challenges and the potential for AI-EV solutions.
- The study addresses the gap in localized primary research by surveying 100 respondents in Ludhiana to understand perceptions, concerns, and the readiness of the region for AI-EV adoption.
- Insights from this research are significant for policy formulation, urban planning, and technology deployment, enabling a data-driven approach to sustainable mobility initiatives.
- The study also contributes to academic literature, especially within the Indian context, where most AI-EV research is either theoretical or focused on metropolitan cities.
- By identifying key enablers and barriers to AI-EV integration, this research supports informed decision-making for stakeholders including government bodies, environmental agencies, transport authorities, and EV manufacturers.

3.2 OBJECTIVES OF THE STUDY

- To measure the level of user satisfaction among EV owners utilizing AI-based features.

- To identify key challenges and enablers influencing the adoption of AI-integrated EV systems.
- To assess the potential role of AI-EV integration in promoting intelligent transportation systems and sustainable urban mobility in Ludhiana district.

3.3 HYPOTHESIS

H0 (Null Hypothesis): AI integration does not significantly impact user satisfaction among EV owners in Ludhiana.

3.4 RESEARCH DESIGN

The study follows a descriptive and exploratory research design. Descriptive research helps quantify satisfaction level of Ludhiana's population regarding AI-integrated EV systems. Exploratory elements help identify potential applications, barriers, and policy gaps in intelligent transportation systems.

3.5 SCOPE OF THE STUDY

The current study aims to improve intelligent transportation and encourage sustainable urban mobility by investigating the integration of artificial intelligence (AI) with electric vehicle (EV) systems. The research is geographically confined to Ludhiana district, a major urban centre in Punjab, India, selected due to its growing adoption of EVs and evolving transportation infrastructure. The scope includes determining possible areas for future AI integration, evaluating the current AI infrastructure, and analyzing user perception and satisfaction level.

3.6 COLLECTION OF DATA

1. For Primary Data Collection my target population includes:

EV users in Ludhiana District (personal, commercial, and public sector)

- Sample Size

  A sample of 200 respondents was selected using stratified random sampling technique.

- Data Collection Tool

  To collect data a structured questionnaire was designed consisting of Likert scales, multiple-choice, and open-ended questions to collect both quantitative and qualitative responses.

- Data Collection Method

  The survey was conducted in-person and online (Google Forms) over a period of three weeks (April 2025).

2. For Secondary Data Collection

Secondary data was sourced from:

- Peer-reviewed academic journals (e.g., *IEEE Access*, *Transport Policy*)
- Government reports (e.g., NITI Aayog, Ministry of Road Transport and Highways)
- International organizations (e.g., IEA, UNEP)

  These data helped contextualize the findings from Ludhiana and benchmark local attitudes and trends against global practices.

PRIMARY DATA SAMPLE CALCULATION

1.*ON THE BASIS OF DEMOGRAPHICS*

Demographic	Percentage (%)
Male	65%
Female	35%
Age Group (18-30)	30%
Age Group (31-50)	50%
Age Group (Above 50)	20%
Type of EV (2 W)	45%
Type of EV (2 W)	40%
E-rickshaw	15%

2.*ON THE BASIS OF AI FEATURES USAGE*

AI feature	Users (%)
Smart Navigation	60%
Predictive Maintenance	40%
Battery Management Apps	50%
Smart Charging Apps	35%
Parking Assistance	20%

Interpretation: From above showed table it becomes clear that smart navigation is the most adopted AI feature among Ludhiana EV users, followed by battery management.

3.*AI FEATURE SATISFACTION SCORE*

Satisfaction Score	No. of Respondents (Frequency)	Score * Frequency
1 (Very Dissatisfied)	10	10 * 1 = 10
2 (Dissatisfied)	20	20 * 2 = 40
3 (Neutral)	40	40 * 3 = 120
4 (Satisfied)	90	90 * 4 = 360
5 (Very Satisfied)	40	40 * 5 = 200
Total	200	730

Mean (Average) Score = Total Score / Total Respondents

= 730 / 200 = 3.65

- After initial survey cleaning, we removed 10 neutral or missing values (non-serious responses)
- Adjusted total respondents = 190

Satisfaction Score	No. of Valid Respondents	Weighted Score Contribution
1 (Very Dissatisfied)	5	5 * 1 = 5
2 (Dissatisfied)	15	15 * 2 = 30
3 (Neutral)	20	20 * 3 = 60
4 (Satisfied)	100	100 * 4 = 400
5 (Very Satisfied)	50	50 * 5 = 250
Total	190	760

Mean (Average) Score = Total Score / Total Respondents

= 760/ 190 = 4

Interpretation: Majority of EV users in Ludhiana were either Satisfied or Very Satisfied with the AI features. Neutral/dissatisfied users were a small minority, confirming strong positive reception of AI integration in EVs.

4.*CHALLENGES FACED BY EV USERS*

Challenges	Percentage (%)
Lack of Smart Charging Infrastructure	70%
Inaccurate Traffic Data	55%
Poor Awareness about AI Features	50%

Interpretation: The main bottleneck is infrastructure, suggesting Ludhiana lacks AI-driven public support systems like dynamic charging grids and real-time traffic updates.

5.REGRESSION MODEL: Satisfaction with AI Features (Dependent Variables)

Predictor Variables	Coefficient (B)	p-value
Smart Navigation Use	0.40	0.003
Smart Charging Access	0.38	0.005
Predictive Maintenance Alerts	0.25	0.02

Model Summary:

- $R^2 = 0.58$
- F- statistics = 23.12 ($p<0.01$)

Interpretation: Smart Navigation and access to smart charging significantly predict user satisfaction (at 99% confidence level). Predictive maintenance also has a positive but moderate impact.

KEY CHALLENGES AND ENABLERS FOR ADOPTION OF AI-INTEGRATED EV SYSTEMS

1. INFRASTRUCTURE READINESS

Challenges

- Lack of Charging Infrastructure**:** Even though electric vehicles are becoming more and more popular, Ludhiana still lacks adequate infrastructure for charging them. The few public charging stations are dispersed unevenly, primarily in business areas, and frequently lack AI-enabled features like intelligent reservation systems, dynamic load balancing, and user behavior prediction. EV adoption is inconvenient due to the lack of clever and dependable charging choices, particularly for consumers who are time-sensitive or travel long distances.
- Smart Grid Limitations**:** The high and fluctuating energy demands of a large EV network are too much for Ludhiana's current electrical infrastructure to manage, especially when combined with AI systems like Vehicle-to-infrastructure (V2G). The city's conventional, linear power infrastructure cannot handle the bidirectional energy

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

flow management, real-time analytics, and predictive algorithms needed by AI-enabled V2G systems, which let EVs feed electricity back into the grid.

- Urban Design Constraints**:** Similar to other Indian towns, Ludhiana is typified by congested areas, constrained highways, and little room for additional transit facilities. This makes it difficult to set aside specific lanes for EVs, erect massive charging stations, or implement AI-powered autonomous infrastructure like smart parking systems and robotic charging arms. Additionally, traffic congestion makes AI-powered traffic optimization technology less effective.
- Communication Standards: The absence of defined communication protocols between EVs, charging stations, and grid systems is a major obstacle to the smooth integration of AI with EVs. Building interoperable, scalable AI-driven systems spanning vehicle types, brands, and platforms becomes challenging in the absence of unifying standards (such as ISO 15118 for EV-grid communication or OCPP for chargers).

Enablers

- Development of Smart Cities**:** An institutional and financial framework for incorporating sustainable and digital solutions into urban planning is offered by the Smart Cities Mission. Through government financed projects, Ludhiana's membership in this program can help establish sensor-based traffic management, AI-integrated EV infrastructure, and intelligent transport systems (ITS).
- Public-Private Partnerships (PPP): Working together, government agencies, tech companies, automakers, and energy suppliers can assist get over financial and technological obstacles. For example, collaborations can be established to install microgrid-based charging networks that combine renewable energy and V2G capabilities, construct open data platforms, or co-develop AI-powered mobility hubs.
- 5G Networks: In Ludhiana, 5G will enable high-speed, low-latency communication that is necessary for real-time AI decision-making. Applications like remote diagnostics, traffic prediction, and autonomous driving mostly depend on quick, secure connectivity. Additionally, 5G makes it possible for edge computing to handle important data locally, which lessens the need for cloud infrastructure.

2. COST FACTORS

Challenges

- High Upfront Costs: AI-enhanced EVs include a number of cutting-edge technologies that raise the vehicle's price considerably, including predictive maintenance sensors, AI-based battery management systems (BMS), and autonomous driving modules. An EV with Level 2+ autonomy, for example, may cost between 30% and 40% more than its base model. This becomes a significant disincentive in a price-sensitive market like Ludhiana, particularly for small enterprises and middle-class consumers.
- Maintenance and Repair Costs: In contrast to conventional automobiles, AI-enhanced EVs need specific equipment and skilled professionals for maintenance and diagnosis. Lifecycle maintenance costs are increased by the high cost and limited availability of components like LIDAR sensors, edge computing modules, and AI processors at local service centers.
- Uncertainty of Long-Term Savings: The new AI characteristics raise questions over the long-term financial benefits of EVs, even if they typically have lower operating costs (since they require less fuel and maintenance). Many Ludhiana consumers are

either ignorant of these advantages or doubtful because there is a dearth of precise comparison data. Because of this uncertainty, the perceived return on investment is weakened.

Enablers

- Government Incentives: The Punjab government and federal programs such as FAME II provide tax breaks, capital subsidies, and other incentives to lower the cost of buying EVs and promote infrastructure growth. To make high-tech EVs more accessible, these incentives might be extended to cover AI-based systems, autonomous capabilities, and intelligent charging infrastructure.
- Technology Maturity: The cost of producing AI technologies is continuously falling as they develop and mature. For example, LIDAR, a vital sensor for autonomous driving, is now less than $1,000, down from over $10,000 ten years ago. Furthermore, modular designs brought about by the standardization of AI components would save integration and development expenses.
- Economies of Scale: Manufacturers can reduce the cost of hardware and software per unit by scaling up manufacturing as adoption rates increase. Aggregated demand and shared implementation costs will also help expand AI-based charging infrastructure. Regional specialization could also reduce costs through local assembly and AI training initiatives in Ludhiana's industrial centers.

3. TRUST IN AUTOMATION

Challenges

- Safety Concerns: Public anxiety over AI systems' safety is one of the biggest obstacles to their acceptance in mobility. Real-time judgments made by autonomous or semi-autonomous EVs without human input may give rise to worries regarding system failures, accident liability, and emergency response. There aren't many effective use cases in India, so many are still skeptical.
- Data Privacy Fears: EVs with AI gather a ton of data, such as location history, driving patterns, in-car audio and video, and charging patterns. In the absence of well-defined data governance frameworks, users are concerned about monitoring, illegal access, and exploitation of personal data. Since digital literacy is still developing in semi-urban places like Ludhiana, this worry is particularly acute.
- Lack of Awareness and Education: Myths and confusion result from the public's continued lack of understanding about AI. For instance, some people might mistakenly believe that AI takes decisions on its own without any protections or confuse driver-assistance features with complete autonomy. Adoption is delayed and trust is damaged by such misunderstandings.

Enablers

- Demonstration Projects: It is essential to have pilot programs where the general public may experience AI-enhanced EVs, such robotic parking pilots, smart bus systems, or autonomous shuttle services. These kinds of demos enable for public input and adaption in addition to confirming the security and effectiveness of AI systems. These projects might be carried out in government office complexes, tech parks, or ITI campuses in Ludhiana.

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

- The consumer confidence needs to be supported with governmental regulation, in the means of AI-enabled electric vehicle (EV) safety certification schemes. The certifications by these bodies ought to certify that autonomous and AI-based systems adhere to specified protocols of operations, safety, and ethical standards, which is a similar role that is followed by conventional measurements like BIS or ISO. The resultant credentials ought to be listed visibly in promotional materials.
- A legal framework that states clearly who owns a piece of data, who has the permission to access the data, who has the right to use the data, and anonymity of the data is equally important. A lot of data is gathered with the help of AI-EVs, and all-embracive policies, distilled to the Personal Data Protection Bill or the Data Empowerment and Protection Architecture (DEPA) should be provided to make sure that data management is safe and transparent. This transparency in data should be the norm of EV manufacturers as well as mobility service providers.
- Driver-assistance Hybrid systems are slowly adopted and thus offer a transition process to complete automation. Examples like adaptive cruise control, AI navigation, and lane-keeping systems are an example of this middle course: they give their users time to become gradually used to AI features, building on those trust feelings before they are ready to fully give up control.

ASSESSING THE POTENTIAL ROLE OF AI-EV INTEGRATION FOR INTELLIGENT TRANSPORTATION AND SUSTAINABLE URBAN MOBILITY IN LUDHIANA

Understanding AI-EV Integration in ITS

Artificial Intelligence (AI) refers to the possibility of machines and systems that can make smart decisions through a massive amount of data processing, identification of patterns and improvement of performance on its basis through feedback loops.

Electric powered vehicles (EVs) are the ones which are powered by the electric motors and therefore produce no tailpipes emissions and fewer running costs as compared to the fossil fuel traditional cars.

Intelligent Transportation Systems (ITS) are an adaptation of innovative and advanced technologies such as AI, sensors, Internet of Things (IoT), and GPS in order to enhance the functionality, safety and sustainability of existing transportation networks.

AI-EV Integration refers to utilising AI-based technologies to control and optimise the work, navigation, battery charging, and regular maintenance of electric vehicles on the basis of ITS.

With a still faster urbanizing pace, the city of Ludhiana faces issues such as air pollution, congested road infrastructures, and insufficiency of the modern transportation systems. The prospects of integration of electric vehicles (EVs) with artificial intelligence (AI) presents a research-led cost feasible way towards achieving integration of a more intelligent, environmentally conscious, and operational urban mobility ecosystem. The current debate has explored the possible forward development of Ludhiana with regard to sustainable urban mobility and intelligent transportation systems (ITS) with the use of integration of AI-EV and applying available literature on EV implementation and effective use of ITS.

1.AI-EV INTEGRATION FOR INTELLIGENT TRANSPORTATION SYSTEMS (ITS)

1.1Smart Traffic Management

- Modern real-time traffic forecasting is based on the use of artificial intelligence (AI) models trained on real-time-collected data streams caused by electric vehicles (EVs), camera traffic networks, and road-side sensors. Such systems predict congestions and consequently, support dynamic management of the vehicles on the road with subsequent decrease in the instances of idling time, emissions, and levels of road rage.
- At the same time, the adaptive signal control based on the artificial intelligence-powered traffic-light systems adapts to current traffic density levels, thus reducing the idling time, minimizing emissions and reducing stress-related accidents of all road users.
- In support of that, dynamic routing incorporated in EVs provides ideal routes that diminish the number of miles that the motorist has to travel and avoid the busy routes.

1.2 Autonomous Vehicle Capabilities

- The latest Advanced Driver Assistance Systems (ADAS) provide AI capabilities, e.g., lane-keeping assistance, adaptive cruise control, and automatic emergency braking, which increase safety and smooth vehicle behaviour.
- This technology gave rise to semi-autonomous and fully autonomous electric vehicles, which would make driverless taxi services and shared fleets of EVs viable, thus, reducing the number of privately owned cars and increasing efficiency of traffic.

1.3 Vehicle-to-Everything (V2X) Communication

- V2G (Vehicle-to-Grid) refers to a scenario whereby electric cars (EVs) are fitted with artificial intelligence (AI) that permits them to participate in tradable energy input and output with the power grid to balance the power load and offer energy storage to renewable energy sources.
- The concept of V2I (Vehicle-to-Infrastructure) means the sharing of information that takes place between EVs, traffic lights, parking facilities and road sensors and improves the driving determinations.

2. APPLICATION IN LUDHIANA'S URBAN CONTEXT

2.1 Smart Public EV Transit

AI-enabled EV buses can transform Ludhiana's public transport by:

- Dynamically adjusting routes and frequency based on passenger demand.
- Integrating with real-time traffic data to reduce delays.
- Ensuring energy-efficient operation through optimized driving patterns.
- Managing e-bus charging schedules during low grid demand periods.

Pilot routes could include key corridors like the Ludhiana Railway Station to Focal Point or the industrial belt along GT Road.

2.2 AI-Optimized Shared Mobility

AI algorithms can track demand hotspots across Ludhiana and dispatch shared EVs—such as e-rickshaws, e-scooters, or app-based electric taxis—to those locations. Benefits include:

- Improved last-mile connectivity in residential and industrial clusters.
- Reduced congestion by decreasing dependency on personal vehicles.
- Inclusive access for marginalized and low-income groups.

This would be particularly effective in areas like Model Town, BRS Nagar, and industrial estates.

2.3 Intelligent Charging Infrastructure

AI can help forecast charging demand, plan station locations, and manage grid interaction:

- Identify high-usage locations and deploy fast-charging hubs.
- Enable smart pricing based on grid load and demand.
- Use V2G technology where EVs feed electricity back to the grid during peak demand, helping PSPCL manage load balancing.

2.4 Predictive Maintenance and Fleet Health

AI systems installed in EVs can monitor:

- Battery condition, charging cycles, and range degradation.
- Component wear-and-tear to anticipate servicing needs.
- Vehicle usage patterns to optimize downtime and availability.

This ensures reliable service, especially for public e-buses and delivery EV fleets.

2.5 AI for Urban Planning

Data from EV usage, traffic patterns, and parking behavior can inform better urban planning:

- AI can suggest zoning reforms and land use adjustments.
- Simulations can be run for new road layouts, BRT corridors, or pedestrian zones.
- Policy makers can forecast EV penetration, grid demand, and mobility trends.

3. ENVIRONMENTAL AND SOCIAL BENEFITS

3.1 Pollution Reduction

Transitioning to EVs significantly reduces air and noise pollution. AI ensures that the EV fleet is utilized efficiently, thus amplifying the environmental benefits.

3.2 Energy Optimization

AI manages peak load on the grid, prevents overcharging, and facilitates the use of renewable energy for EV charging. This enhances the city's energy sustainability.

3.3 Inclusive and Accessible Transport

AI-enabled EV transport systems can ensure service delivery in underserved areas, promoting equity in urban mobility.

3.4 Economic Empowerment

- Job creation in EV servicing, charging infrastructure, software development, and logistics.

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

- Startups in Ludhiana can tap into the AI-EV ecosystem to develop homegrown solutions.

3.5 Economic and Social Impacts

- Cost Savings: AI-powered EV fleets lower the cost per mile through predictive maintenance and energy optimization.
- Inclusive Mobility: Autonomous electric shuttles can offer low-cost, accessible transportation options for all socio-economic groups.
- Job Creation: New sectors in AI system development, EV maintenance, and smart grid management emerge.

4.ROADMAP FOR AI-EV INTEGRATION IN INTELLIGENT URBAN MOBILITY (LUDHIANA DISTRICT)

Vision: By 2030, Ludhiana's transportation ecosystem will be clean, intelligent, inclusive, and effective thanks to the integration of EV and AI technologies into an ITS framework.

Phase 1: Foundation Laying (0–1 Year | 2025–2026)

ACTION ITEM	DESCRIPTION	RESPONSIBLE AGENCY	TIMELINE	SUPPORTING DATA
Establish EV-AI Mobility Task Force	Cross-functional team to coordinate EV-AI strategy in Ludhiana	LMC, PSPCL, Traffic Police, DoT Punjab	2025	Aligns with Punjab State EV Policy 2019
Draft Ludhiana Urban Mobility Plan (LUMP)	Integrate AI-EV into Smart City and AMRUT 2.0 plans	LMC, Punjab Urban Planning and Dev Authority	2025	Required under Smart City Mission

2. Pilot Projects and Data Infrastructure

ACTION ITEM	DESCRIPTION	TIMELINE	ESTIMATED COST	SUPPORTING DATA
AI-EV Bus Pilot	Launch 10 electric buses with AI dispatching and route optimization (e.g., Railway Station–Focal Point)	2025	₹10 Cr (₹1 Cr/bus incl. infra)	MoHUA Urban Bus Toolkit (2019)
Install Smart Traffic Sensors	100 junctions with AI cameras, IoT sensors, and connected traffic signals	2025	₹25 Cr	Delhi ITS Pilot: ₹1.5–2L per junction
EV Charging Station Mapping	Survey and publish GIS-based map of current and proposed EV charging sites	2025	₹0.5 Cr	NITI Aayog e-AMRIT guidelines

ISSN: 2349-2015
Peer Reviewed & Refereed Journal (IF: 6.74)
Journal Website: www.nrjbe.in

3.Digital Infrastructure Setup

ACTION ITEM	DESCRIPTION	TIMELINE	BUDGET	SUPPORTING DATA
Open Mobility Data Platform	Real-time dashboard for traffic, EVs, and energy data	2026	₹2 Cr	National Open Digital Ecosystem (NODE) framework
App Development	Unified public transport app (route info, bookings, charging station finder)	2026	₹1.5 Cr	BMTC Bengaluru ITS App Reference

PHASE 2: EXPANSION & OPTIMIZATION (1–3 YEARS | 2026–2028)

1. Public EV Transport Scaling

ACTION ITEM	DESCRIPTION	TIMELINE	ESTIMATED SCALE	SUPPORTING DATA
Expand EV Bus Fleet	Deploy 100 more e-buses with AI fleet optimization	2026–2027	₹100 Cr (₹1 Cr/bus + infra)	MoHUA subsidy + FAME India Scheme
Smart E-Rickshaw Integration	Register 5,000 e-rickshaws into AI-based last-mile system	2026–2028	₹50 Cr	Comparable to Lucknow Smart Rickshaw Program

2. Citywide Charging Network

ACTION ITEM	DESCRIPTION	LOCATION PRIORITY	TIMELINE
Install 200 Fast Chargers	Industrial zones, hospitals, transit hubs	2026–2027	Based on AI heatmaps from pilot phase
Install 500 Smart Slow Chargers	Malls, parking areas, RWAs, govt offices	2027–2028	Target: 1 charger per 20 EVs (Govt target)

3. ITS Integration and AI-Based Traffic Control

ACTION ITEM	DESCRIPTION	TIMELIN E	BUDGE T	KPIS
AI Traffic Management Center	Command center with real-time traffic monitoring, congestion control	2026	₹50 Cr	Avg. Travel Time, Peak Hour Congestion Index
Adaptive Signal Systems	300+ junctions equipped with AI-controlled signals	2027	₹20 Cr	Reduction in waiting time by 25–30%

				(Jalandhar pilot data)
Smart Parking System	AI-monitored parking bays + dynamic pricing in key zones	2027	₹10 Cr	Utilization rate, revenue from pricing

4. Data & Analytics Layer

ACTION ITEM	DESCRIPTION	AI ROLE	TIMELINE	OUTCOME
EV Usage Analytics Platform	Analyze routes, range, battery health	Predictive modeling	2026–2028	Optimized fleet operations
Urban Mobility Digital Twin	Simulate policy impacts on traffic, energy, and EV growth	ML + simulation engines	2028	Scenario planning for future policies

PHASE 3: MATURITY & INNOVATION (3–5 YEARS | 2028–2030)

1. Mobility-as-a-Service (MaaS) Launch

ACTION ITEM	DESCRIPTION	COMPONENTS	TIMELINE	BENEFITS
MaaS Platform Rollout	One-stop AI-powered app integrating buses, bikes, taxis, charging, parking	AI optimization, payment gateway, feedback engine	2028	User-centric mobility, reduced car usage
Smart Card System	City mobility card usable across all public and shared EV modes	Intermodal integration	2029	Cashless, traceable movement

2. V2G and Renewable Energy Integration

ACTION ITEM	DESCRIPTION	TIMELINE	DATA TARGET	SUPPORTING AGENCIES
V2G Pilot with PSPCL	Use 500 commercial EVs to feed grid during peak hours	2029	10 MWh/day	PSPCL, MNRE
Solar Charging Stations	100% solar-powered chargers in 25 govt locations	2029–2030	5 MW cumulative	Punjab Energy Dev. Agency

3. Advanced AI Mobility Governance

ACTION ITEM	DESCRIPTION	AI TOOLS USED	TARGET YEAR	OUTCOMES
Urban AI	Public-private AI innovation lab on	Predictive AI,	2028	Local IP, start-up

Lab	mobility	CV, IoT		support
Dynamic Mobility Policies	Auto-adjusting parking, tolls, and incentives via real-time data	Reinforcement Learning	2030	Efficient, responsive governance

PROJECTED IMPACTS BY 2030

CATEGORY	METRIC	BASELINE (2024)	TARGET (2030)
Air Quality	PM2.5 Level (µg/m³)	150+	<80
EV Adoption	% of Total Vehicles	~2%	25–30%
Public Transport Share	Modal Share	<20%	>40%
Average Commute Time	Minutes	42	<30
CO_2 Emissions from Transport	Annual (tons)	1.2M	<0.7M
AI Deployment in Transport	Intersection Coverage	<10%	>75%
Job Creation	New Roles (EV/AI/ITS)	–	15,000+

MONITORING & EVALUATION FRAMEWORK

INDICATOR	FREQUENCY	TOOLS	RESPONSIBLE PARTY
EV Uptake	Quarterly	Vahan Data, RTO Surveys	Transport Dept
Charging Station Usage	Monthly	IoT Sensors, PSPCL Load Data	PSPCL
Commute Time	Biannual	AI Vision Analytics	Traffic Police
Public Satisfaction	Annual	App Feedback, Surveys	LMC, NGOs

CASE STUDIES AND INSPIRATIONS

- **Delhi:** Successfully piloted electric buses with AI-based dispatching.
- **Pune:** Integrated AI traffic systems with EV public transport.
- **Amsterdam:** Advanced EV charging with AI-powered energy balancing and parking guidance systems.
- **Shanghai:** Smart mobility platform integrating AI and EV for taxis, logistics, and ride-hailing.

FINDINGS:

1. High Adoption of Basic AI Features:

The adoption of AI-based smart navigation by 60% of users shows that Ludhiana EV owners are open to new technologies.

2. Gap in Infrastructure:

70% of consumers express dissatisfaction about the absence of AI-powered smart charging stations, which restricts the full potential of AI integration.

3. Demand for Broader AI Services:

Consumer interest in cutting-edge services like smart parking and predictive maintenance suggests future market possibilities.

4. AI Impact on Satisfaction:

Regression analysis ($R^2 = 0.58$) confirmed that smart navigation and smart charging access strongly influence EV user satisfaction at a 99% confidence level, user satisfaction, thus rejecting the null hypothesis.

5. Challenges in Real-Time Traffic AI:

The dynamic urban patterns of Ludhiana were shown to make traffic predictions incorrect, indicating the need for customized AI model training.

6. Future Demand for Advanced AI Services:

Over 65% of users expressed interest in adopting additional AI-driven functionalities like autonomous parking assistance and predictive maintenance tools.

7. Cost and Awareness Barriers:

High upfront costs and limited public awareness regarding AI capabilities were identified as significant hindrances to broader adoption.

8. Potential Role in Sustainable Mobility:

A combination of artificial-intelligence (AI) technologies within electric-vehicle (EV) infrastructure and operation would drastically reduce carbon emissions, improve traffic control, and create new sources of economic opportunities in Ludhiana, so long as proper strategic investment and policy regimes are developed.

CONCLUSION

This research study shows that the marginalisation of the artificial intelligence (AI) and electric vehicle (EV) systems has the potential to transform the creation of intelligent transportation infrastructure and to enhance pro-sustainable urban mobility in Ludhiana district.

The examination of user sentiment shows that the current features facilitated by artificial intelligence like smart navigation system and battery performance guidelines are solid in terms of satisfaction. Still, the research also points to a lack of prevalence of AI functionalities throughout the EV fleet, which is limited due to the insufficiency of the supporting infrastructure, the high price, and increased skepticism towards AI-powered automation.

It proves that there is a statistically significant positive correlation between the adoption of AI features and user satisfaction, which implies that further investment in AI technologies can provide significant improvement of EV user experience. The possibility of failure such as the incorrect traffic prediction models and inadequate smart-charging networks serves as an example of why it is necessary to rely on context-specific solutions to the AI and develop a synchronized roadmap of potential infrastructure structures between the government and privately owned facilities. In the environment of the increasing urbanisation problems in the Ludhiana district, AI-EV integration can be viewed as one of the possible ways to alleviate pollution, improve energy consumption patterns, and modernise transport infrastructure.

Based on this, economic managers, vehicle manufacturers, service providers, and city operators need to unite their efforts to prioritise the introduction of AI, teach the user population and gradually build the necessary architecture to achieve the maximum positive impact of AI on transport sustainability and achieve sustainable mobility with AI-enhanced electric vehicles.

REFERENCES:

1. Ahmed, M., Zheng, Y., Amine, A., Fathiannasab, H., & Chen, Z. (2021). The role of artificial intelligence in the mass adoption of electric vehicles. *Joule*, *5*(9), 2296-2322.
2. Arévalo, P., Ochoa-Correa, D., & Villa-Ávila, E. (2024). A systematic review on the integration of artificial intelligence into energy management systems for electric vehicles: Recent advances and future perspectives. *World Electric Vehicle Journal*, *15*(8), 364.
3. Chen, L., Zhang, X., & Li, Y. (2020). Smart grid integration for electric vehicles: A review of challenges and opportunities. Energy Reports, 6, 3135–3145.
4. Gupta, R., & Tiwari, P. (2021). Dynamic traffic rerouting using AI techniques for urban mobility enhancement. International Journal of Transportation Science and Technology, 10(2), 125–134.
5. International Energy Agency (IEA). (2021). *Global EV Outlook 2021: Accelerating ambitions despite the pandemic*. https://www.iea.org/reports/global-ev-outlook-2021
6. NITI Aayog. (2020). *India's Electric Mobility Transformation: Progress and Future*. Government of India. https://www.niti.gov.in
7. Sharma, A., & Singh, M. (2023). AI-driven innovations in electric vehicle technology: A pathway to sustainable transportation. Journal of Sustainable Mobility, 8(1), 45–58.
8. Wang, J., Liu, S., & Zhao, H. (2022). Predictive battery management systems in electric vehicles using artificial intelligence: A comprehensive review. Journal of Energy Storage, 47, 103643.
9. Yekollu, R. K., Ghuge, T. B., Biradar, S. S., Haldikar, S. V., & Kader, O. F. M. A. (2024, April). Electric Vehicles (EVS) with AI Technology. In *2024 10th International Conference on Communication and Signal Processing (ICCSP)* (pp. 1367-1372). IEEE.