International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 7, No. 04 July-Aug; 2025 Page. No. 299-311

To cite this article: Prof. Y. MuniRaju and * Mr. Malleshi H (2025). AI DRIVEN INNOVATIONS OF BRT MODE IN TRANSPORTATION SYSTEM, International Journal of Research in Commerce and Management Studies (IJRCMS) 7 (4): 299-311 Article No. 456 Sub Id 834

AI DRIVEN INNOVATIONS OF BRT MODE IN TRANSPORTATION SYSTEM

Prof. Y. MuniRaju[1] and * Mr. Malleshi H[2]

[1]Senior Professor, Department of Commerce, Mangalagangotri, Konaje, Mangalore, Dakshina Kannada 574199

[2]Research Scholar, Department of Commerce, Mangalagangotri, Konaje, Mangalore, Dakshina Kannada 574199

DOI: https://doi.org/10.38193/IJRCMS.2025.7421

ABSTRACT

The rapid pace of urbanization in India has intensified the demand for efficient, safe, and inclusive public transport systems. In response, the Bus Rapid Transit System (BRTS) has emerged as a viable solution, especially in Tier-2 cities like Hubli-Dharwad. This study explores the role of artificial intelligence (AI) in enhancing the operational efficiency, commuter satisfaction, and safety of the Hubli-Dharwad BRTS (HDBRTS), Karnataka's first BRTS initiative. Using a mixed-methods approach that integrates primary data from 200 commuters and secondary data from official and academic sources, the research investigates awareness levels, usage patterns, and perceptions of AI-driven services such as real-time tracking, predictive maintenance, contactless ticketing, and smart surveillance. Statistical tools like Chi-square tests and one-sample t-tests reveal strong commuter agreement on the punctuality, reliability, and service quality of AI-enabled BRTS. However, the study also identifies significant variation in awareness and satisfaction based on socio-economic factors such as income, occupation, and gender. While users highly value punctuality and transparency, areas like AI awareness, safety infrastructure, and network expansion require targeted improvements. The findings suggest that HDBRTS is not only transforming urban mobility but also setting a replicable model for sustainable and intelligent transit in similar urban environments. Strategic investments in public education, route extension, and AI-based system optimization are recommended to strengthen the system's impact further.

KEYWORDS: AI in public transport, BRTS, Chi-square tests, one-sample t-tests, AI awareness

INTRODUCTION

Urban mobility and public transportation networks in India are under great strain from fast urbanization and population increase. The Bus Rapid Transit System (BRTS) has developed as a reasonably priced and efficient public transportation option meant to offer quicker, safer, and more dependable bus services to meet these issues. Operating on dedicated lanes, BRTS lets buses skip

traffic congestion, therefore enhancing commuting time, fuel economy, and general passenger pleasure. First put into practice in India in 2006, the idea of BRTS was pioneered by Ahmedabad (Gujarat) using the Janmarg BRTS (Web: http://www.hdbrts.co.in), which became a model for other cities because of its high-quality infrastructure, smart traffic control, and integration with different means of transportation. Many Indian cities have since adopted the BRT idea to update urban transit. Hubli-Dharwad BRTS (HDBRTS) "CHIGARI" started running in Karnataka in October 2018. Implemented under the Smart Cities Mission and Jawaharlal Nehru National Urban Renewal Mission (JnNURM), it is the first BRTS project in Karnataka. Spanning about 22.25 kilometers, the HDBRTS corridor links important transit centres and lowers traffic congestion along the high-demand corridor. Operating with a fleet of over 100 buses, including low-floor, semi-low-floor, and air-conditioned buses fitted with Intelligent Transport Systems (ITS), the system runs efficiently and reliably. BRTS has been started in more than 15 Indian states as of 2024, with operational lines in cities including Pune, Indore, Bhopal, Rajkot, Surat, Jaipur, and Raipur, among others. (Seyed Mohammad & Et.al (2010) Every one of these initiatives aims to boost public transportation use, lower reliance on private cars, and support sustainable urban growth.

Artificial intelligence (AI) in BRTS under the Smart City Yojana has transformed how these systems run. AI-driven innovation refers to the integration of advanced AI technologies to design, operate, and improve public transportation systems, enhancing their adaptability, efficiency, safety, and responsiveness. Real-time tracking, automated fare collecting, predictive maintenance, AI-driven scheduling, and smart surveillance all leverage AI technologies, which improve the system's efficiency and commuter friendliness. Features like real-time arrival information, shorter wait times, more safety, and better service dependability help commuters. This study is to investigate commuter feedback and satisfaction, the socio-economic profile of BRTS customers, and the part artificial intelligence plays in improving BRTS operations. The results will help to clarify how AI-driven innovations could change public transportation systems in tier-2 Indian cities such as Hubli-Dharwad, hence enhancing their intelligence, safety, and sustainability.

SELECTED REVIEWS

This review focuses on the performance, commuter experience, and impact of the Hubli-Dharwad BRTS (HDBRTS) since its implementation in 2018 under the Smart Cities Mission.

Dr. D. D. Kulkarni, Dr. R. I. Turamari, and Dr. V. S. Kulkarni conducted a study titled *"Passengers' Satisfaction towards the Services of BRTS in Hubballi-Dharwad"*, focusing on assessing commuter satisfaction with the operational aspects of the BRT system in the twin cities. The research highlighted the effectiveness of the BRTS in improving urban mobility and reducing traffic congestion. Their findings indicated that a majority of passengers were satisfied with the punctuality,

cleanliness, safety, and affordability of the services. The study also emphasized the importance of continuous improvements in infrastructure and AI-enabled features to enhance service delivery and meet the growing expectations of urban commuters. The authors suggested that the success of BRTS in Hubballi-Dharwad can serve as a model for other tier-2 cities in India.

Seyed Mohammad et al. (2010) examined the establishment and necessity of the Bus Rapid Transit System (BRTS) in Tehran. Their study concluded that passengers expressed a high level of satisfaction with the services provided by BRTS in the city.

Sushanshu et al. (2017) evaluated passenger perceptions of BRTS services in Indore. Their findings highlighted the importance of dedicated lanes for BRT operations and emphasized the need for increasing the number of buses to meet growing commuter demand.

Arpit Sharma and H. S. Goliya (2018) conducted a study to assess user satisfaction with BRTS in Indore city. They observed that although BRTS provides quality service, its implementation remains limited to only a few cities in India, indicating a need for wider adoption.

In the existing literature and reviews from Karnataka, no comprehensive study has focused specifically on AI-driven innovations in the Hubli-Dharwad BRT system. While some articles address commuter perceptions or general public transport services, none have explored the role of artificial intelligence in enhancing BRT operations in this region.

OBJECTIVES OF THE STUDY

1. To study the social status of the respondents
2. To study the role of AI and Innovation in BRT system
3. To analyze the daily commuter's opinion and feedback about the BRT system

HYPOTHESIS OF THE STUDY

H_0: There is **no significant relationship** between AI-driven innovations in the BRT system and the commuters' opinion, feedback, or satisfaction levels, regardless of their social status.

H_1**:** There is a significant relationship between AI-driven innovations in the BRT system and the commuters' opinion, feedback, or satisfaction levels, influenced by their social status**.**

SCOPE OF THE STUDY

The scope of this study is center on evaluating the impact, challenges, and potential of AI-driven innovations in the Bus Rapid Transit System (BRTS), with a specific focus on the **Hubli-Dharwad BRTS (HDBRTS)**. This study aims to understand how artificial intelligence is transforming public

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transportation, improving operational efficiency, enhancing commuter experience, and addressing urban transport challenges in a Tier-2 Indian city context. The study is geographically confined to the **twin cities of Hubli and Dharwad** in Karnataka, where the BRT system has been operational since 2018. (Kulkarni, D. D., Turamari, R. I., & Kulkarni,) The scope includes urban routes within the HDBRTS network, stations, and AI-enabled services available to the public. The study covers AI-driven innovations such as **Real-time bus tracking and GPS integration, Predictive analytics for scheduling and maintenance**, **Smart surveillance systems** (CCTV with AI analytics), **Digital information boards and announcement systems**, **Contactless ticketing and mobile app integration**. The research assesses the maturity and effectiveness of these technologies in delivering efficient and safe transport services.

METHODOLOGY

This study adopts a **mixed-methods approach**, integrating both **primary and secondary data** to investigate the role of artificial intelligence (AI) in transforming the Bus Rapid Transit System (BRTS) in Hubli-Dharwad. The methodology is designed to assess the operational effectiveness, commuter satisfaction, safety enhancement, and technological perceptions linked to AI-driven innovations in the HDBRTS.

The primary data was collected directly from 200 daily commuters of the Hubli-Dharwad BRTS using a structured questionnaire. The questionnaire comprised both open-ended and closed-ended Likert scale questions, categorized into sections such as demographic profile, travel behavior, awareness of AI, and perception of AI-based services, and satisfaction levels before and after AI implementation. The sampling method employed was convenience sampling, ensuring a diverse representation across different age groups, occupations, and income levels. This approach enabled the researcher to capture a balanced and representative view of commuter experiences and expectations regarding AI-integrated public transport.

In terms of data collection techniques, field surveys and direct interactions with passengers were conducted at selected high-footfall BRTS stations during peak hours. Respondents were given clear instructions to answer questions based on their regular experiences with the system. This ensured reliability and authenticity of the primary data collected.

The secondary data was obtained from various credible sources, including official reports from the Hubli-Dharwad BRTS website, policy documents from urban transport authorities, existing scholarly literature on AI applications in public transport, and government publications related to transport infrastructure and smart city initiatives. These sources provided the necessary background, technical context, and operational metrics of the BRTS, as well as insights into AI policies and comparative studies in similar urban environments. The study focuses on the commuting population of the Hubli–

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Dharwad Bus Rapid Transit System (HDBRTS), which serves an average of approximately 90,000 passengers per day. On average, around 5,625 passengers travel per hour, with services operating from 6:00 AM to 10:00 PM. This daily ridership represents the target population for the present research. The collected data was coded and analyzed using SPSS version 24. To assess the reliability of the questionnaire, Cronbach's Alpha test was employed, yielding a reliability coefficient of 0.786, indicating a high level of internal consistency of the instrument.

ANALYSIS

Demographic Background of the Respondents

The study analyzed data from 200 regular or occasional users of the Hubli-Dharwad BRTS system. The results showed that the younger population, particularly students and young professionals, largely depend on the system for daily commuting. Females (55%), a minority, slightly outnumbered males (45%). The occupational profile of respondents showed that students (30%), employees (20%), professionals (15%), and homemakers (15%) are the largest users. The monthly income distribution showed that the BRTS is predominantly used by low- and middle-income groups, making it an affordable and accessible mode of public transport. The high daily usage of the system suggests that it serves as a primary mode of transport for a large urban population.

Table 1 Demographic Characteristics of the respondents

Variable	Characteristics	Frequency	Percentage (%)
Age Group	Below 25 years	60	30.0
	26–35 years	60	30.0
	36–50 years	40	20.0
	Above 51years	40	20.0
Gender	Male	90	45.0
	Female	110	55.0
Occupation	Student	60	30.0
	Employees	40	20.0
	Home maker	30	15.0
	Business	20	10.0
	Professionals	30	15.0
	Others	20	10.0
Monthly Income	Less than ₹10,000	70	35.0

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	₹10,001 – ₹25,000	60	30.0
	₹25,001 – ₹40,000	50	25.0
	₹40,001 – ₹50,000	10	10.0
	Above ₹50,001	10	10.0
Frequency of BRT Use	Daily	100	50.0
	3–4 times a week	25	12.5
	1–2 times a week	50	25.0
	Rarely	25	12.5

(Source: Primary Data)

Descriptive analysis of the social status of the respondents

Descriptive statistics and normality assessments were performed on five variables: age, gender, occupation, income, and frequency of travel, using data from 200 respondents. This analysis aimed to understand the distribution patterns, central tendencies, and variability of the demographic and travel-related data. The age variable showed a mean of 2.45 and a median of 2.00, with a standard deviation of 1.20. Although the Shapiro-Wilk test ($W = 0.829$, $p < .001$) indicated a significant departure from normality, the closeness of the mean and median suggests a slightly skewed but relatively balanced distribution. Gender, coded as 1 = Male and 2 = Female, had a mean of 1.60 and median of 2.00. The standard deviation was 0.491. The Shapiro-Wilk test result ($W = 0.622$, $p < .001$) confirmed non-normality, which is typical for binary data. The mean value reflects a slight male predominance in the sample. Occupation presented a mean of 2.47, a median of 2.00, and a relatively high standard deviation of 1.52, with values ranging from 1 to 6. The Shapiro-Wilk test ($W = 0.835$, $p < .001$) revealed a significant deviation from normality, suggesting variability across occupational categories, possibly due to uneven distribution among groups. Income recorded a mean of 2.48 and a median of 3.00, with a standard deviation of 1.19, indicating moderate dispersion. The test for normality ($W = 0.825$, $p < .001$) showed that the income data was not normally distributed and slightly left-skewed, implying that a larger portion of respondents might belong to lower-income groups. The frequency of travel variable showed a mean of 1.92, a median of 2.00, and a standard deviation of 0.999. As with the other variables, the Shapiro-Wilk test ($W = 0.796$, $p < .001$) indicated a non-normal distribution. The data shows a moderate spread in how often respondents use the transportation service. Overall, the Shapiro-Wilk test results for all variables were significant ($p < .001$), confirming that none of the variables followed a normal distribution. This highlights the need to use non-parametric statistical methods in the subsequent stages of data analysis.

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Table 2 Descriptive analysis of the social status of the respondents

Descriptive analysis					
	AGE	GENDER	OCCUPATION	INCOME	FREQUENCY TRAVEL
N	200	200	200	200	200
Missing	0	0	0	0	0
Mean	2.45	1.60	2.47	2.48	1.92
Median	2.00	2.00	2.00	3.00	2.00
Standard deviation	1.20	0.491	1.52	1.19	0.999
Minimum	1	1	1	1	1
Maximum	4	2	6	4	4
Shapiro-Wilk W	0.829	0.622	0.835	0.825	0.796
Shapiro-Wilk p	<.001	<.001	<.001	<.001	<.001

(Source: Primary data)

Chi Square Test between Gender and awareness of AI Based services in BRT as faster than other public buses

The results of the chi-square goodness-of-fit test indicate a statistically significant deviation in the distribution of responses regarding the awareness, service quality, and speed of the BRTS system compared to other public buses. With 82.5% of respondents selecting Level 3, the data reflects a strong consensus in favor of the BRTS across the evaluated dimensions. The minimal representation at levels 4, 5, and 6 further emphasizes that only a small proportion of users held neutral or less favorable views. The high chi-square value ($\chi^2 = 566$) and the highly significant p-value ($p < .001$) confirm that this distribution is not due to random variation, but rather represents a meaningful pattern of public perception. Overall, the analysis reveals a clear and overwhelming preference among users, indicating that the BRTS system is widely perceived as more efficient, better in service delivery, and faster than other public transport options in the region.

Table 03 Chi Square Test between Gender and awareness of AI Based services in BRT as faster than other public buses

Proportions - **Awareness, Services, faster than other public buses**		
Level	**Count**	**Proportion**
3	264	0.8250
4	14	0.0437
5	28	0.0875
6	14	0.0437

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Chi Square Test Results

χ^2 Goodness of Fit		
χ^2	**df**	**p**
566	3	<.001

Chi Square Test between Income and awareness of AI Based services in BRT as faster than other public buses

The chi-square goodness-of-fit test was conducted to examine whether the distribution of respondents' perceptions across four levels—regarding **awareness, quality of services, and belief that the BRTS is faster than other public service buses**—significantly deviates from a uniform or expected distribution. The observed data reveals a highly skewed pattern, where a majority of the respondents (83%) rated these aspects at Level 3, indicating a strong concentration of neutral or moderate responses. Only a small proportion rated the attributes at higher levels: 8.5% at Level 4, 5.7% at Level 5, and just 2.8% at Level 6. The chi-square test statistic is **$\chi^2 = 889$** with **3 degrees of freedom**, and a **p-value < .001**, which is statistically significant. This suggests that the observed distribution is not due to random chance and that there is a **strong deviation from uniformity**, pointing to a real underlying pattern in respondents' perceptions. This result may also reflect **income-related disparities**, as individuals from lower-income groups might have different expectations or access to information and services than higher-income groups, influencing their ratings. The dominance of Level 3 could imply that while BRTS services are widely known, there may be **limited satisfaction or perceived benefit** across income levels, prompting more neutral ratings rather than strongly positive feedback. Thus, income could be a mediating factor in shaping the perception of BRTS service advantages, awareness, and speed

Table 04 Chi Square Test between Income and awareness of AI Based services in BRT as faster than other public buses

Proportions - Awareness, Services, Faster than other public services buses		
Level	**Count**	**Proportion**
3	410	0.8300
4	42	0.0850
5	28	0.0567

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6	14	0.0283

Chi Square Test Results

χ^2 Goodness of Fit		
χ^2	**df**	**P**
889	3	<.001

Chi Square Test between Occupation and awareness of AI Based services in BRT as faster than other public buses

A chi-square goodness-of-fit test was conducted to examine the distribution of responses across four levels (3 to 6) for the combined attributes of **awareness**, **services**, and **perceived speed advantage** of BRTS over other public bus services, in relation to **occupational categories** of respondents. The observed frequencies were as follows: Level 3 received the highest number of responses (384 or 77.42%), suggesting a strong overall agreement among respondents regarding the effectiveness and speed of BRTS. In contrast, only 56 respondents (11.29%) selected Level 4, and Levels 5 and 6 had 28 responses each (5.65% each), indicating fewer respondents perceive BRTS with increasingly higher effectiveness or awareness. The calculated chi-square statistic was $\chi^2 = 731$ with 3 degrees of freedom, and the p-value was $< .001$, signifying that the distribution is significantly different from a uniform distribution. When analyzed across occupational lines (e.g., students, employed professionals, business owners, and daily wage workers), the disproportionately high response at Level 3 may reflect a shared perception across occupational groups of BRTS being dependable and superior to other public buses in terms of service speed and awareness. However, it's likely that students and regular commuters—who interact most frequently with BRTS—are the ones contributing most to this skew, valuing punctuality and service quality more acutely. On the other hand, the relatively smaller proportions at Levels 4, 5, and 6 may reflect variability in satisfaction levels among business owners or less frequent users, whose priorities might differ (e.g., flexibility or door-to-door access). Overall, the test suggests a statistically significant, occupation-influenced concentration of positive perception at the baseline satisfaction level, highlighting BRTS's success in meeting fundamental commuter expectations across professional segments.

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Table 05 Chi Square Test between Occupation and awareness of AI Based services in BRT as faster than other public buses

Proportions - Awareness, Services, Faster than other public services buses		
Level	**Count**	**Proportion**
3	384	0.7742
4	56	0.1129
5	28	0.0565
6	28	0.0565

Chi Square Test Results

χ^2 Goodness of Fit		
χ^2	**df**	**p**
731	3	<.001

Perception towards AI based BRT Services

A **one-sample t-test** was conducted to evaluate whether the mean ratings for various service attributes of the BRTS system significantly differ from zero, which represents the null hypothesis H_0:μ=0, assuming no perception or neutral opinion. The test was applied to eight key service indicators: *Punctuality, Commute Better, System Transparency, Breakdown Management, CCTV Surveillance, AI Innovation, Commuter Convenience*, and *Service Expansion*. The results showed that all variables had **highly significant t-values** ($p < .001$), confirming that the sample means differ substantially from zero and that respondents hold strong perceptions in each of these service dimensions. Among these, *Punctuality* recorded the highest t-value (t = 79.3) with a mean difference of 4.53, indicating that passengers overwhelmingly perceive the BRTS as highly punctual. Similarly, *Commute Better* and *System Transparency* each had t-values of 70.9 and mean differences of 4.46, suggesting that commuters recognize notable improvements in travel efficiency and clarity in system operations. *Breakdown Management* also received favorable perception (t = 62.4, mean = 3.51), indicating confidence in the system's reliability during disruptions. The remaining attributes—*CCTV* (t = 40.5), *AI Innovation* (t = 45.6), *Commuter Convenience* (t = 42.6), and *Service Expansion* (t = 23.2)—though slightly lower in t-values, still demonstrated statistically significant and positive mean differences, with values ranging from 2.65 to 3.20. These results collectively reveal that respondents perceive BRTS services as highly functional and innovative, especially in core operational areas, while areas like AI integration and network expansion show scope for further development.

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Table 06 One sample T -test Results

One Sample T-Test					
		Statistic	df	p	Mean difference
PUNCTUALITY	Student's t	79.3	199	<.001	4.53
COMMUTE BETTER	Student's t	70.9	199	<.001	4.46
SYSTEM TRANSPARENCY	Student's t	70.9	199	<.001	4.46
BREAKDOWN	Student's t	62.4	199	<.001	3.51
CCTV	Student's t	40.5	199	<.001	3.20
AI INNOVATION	Student's t	45.6	199	<.001	3.19
COMMUTER CONVIENT	Student's t	42.6	199	<.001	3.18
EXPANDED	Student's t	23.2	199	<.001	2.65

Note. H_a $\mu \neq 0$

(Source: Primary data)

FINDINGS

1. **Demographic Profile of Respondents**: The majority of BRTS users in Hubli-Dharwad belong to the youth segment, with 60% aged below 35. Female commuters (55%) slightly outnumber males (45%), reflecting growing gender diversity in public transport use. Occupations such as students (30%), employees (20%), and homemakers (15%) are the predominant user groups, and a large portion (65%) belong to low- and middle-income categories (earning below ₹25,000/month), confirming that BRTS serves as an affordable mode of transport for economically constrained segments.
2. **AI Awareness and Perceived Superiority**: Chi-square tests conducted between **gender**, **income**, and **occupation** against awareness of AI-driven services showed statistically significant deviations ($p < .001$), particularly with most responses clustered at Level 3, reflecting a dominant public perception that BRTS is faster and superior to other public buses. However, the differences across occupational and income lines indicate that social status mediates the level of awareness and perception of AI's impact.
3. **Strong Positive Perception of BRTS Features**: The **one-sample t-test** results showed that commuters perceive significant benefits from the AI-integrated services. Key features like *punctuality (mean diff = 4.53), commuting convenience (mean = 4.46), and system transparency* (mean = 4.46) scored the highest. Lower but still significant scores were found for ***AI innovation***

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(mean = 3.19) and ***network expansion*** (mean = 2.65), indicating satisfaction but also scope for enhancement.

4. **Impact on Rural Connectivity**: A one-sample t-test on the variable *rural transport* produced a high t-value (t = 47.4), highlighting a strong agreement that BRTS has improved rural and peripheral urban area connectivity, aiding equitable access to transportation.

SUGGESTIONS

1. **Enhance AI Awareness Campaigns**: While the majority recognizes AI-based improvements, deeper awareness is needed, especially among lower-income and older occupational groups. Public campaigns through digital boards, social media, and community outreach should focus on explaining AI features and their benefits.
2. **Expand BRTS Network Coverage**: The relatively low mean score for *expansion* (2.65) highlights a gap in geographical coverage. Authorities should explore extending corridors into underserved or densely populated areas to improve inclusivity.
3. **Improve Real-Time User Interfaces**: Although features like real-time tracking and contactless ticketing exist, continued UI/UX improvements of mobile apps and digital kiosks could increase usability, especially for elderly or first-time users.
4. **Introduce Feedback-Driven AI Models**: Incorporate passenger feedback loops into AI systems to improve dynamic scheduling, crowd management, and predictive maintenance. This would make the system more adaptive and commuter-centered.
5. **Safety Through Surveillance**: Investment in AI-powered CCTV surveillance and incident alert systems should be scaled up, especially given moderate ratings on *safety* features like CCTV (mean = 3.20). Gender-sensitive surveillance strategies can help improve night-time travel safety.
6. **Professional Training for Staff**: Staff operating AI-enabled tools should be periodically trained to ensure optimal usage of Intelligent Transport Systems (ITS) and assist passengers with tech-based features.
7. AI-driven innovations also extend to other transportation systems such as auto-rickshaws and KSRTC services in Hubli-Dharwad. **These technologies contribute to enhancing safety and security, particularly for women and elderly travelers**, and allow family members to monitor the movement of the vehicle in real time.

CONCLUSION

This study reveals that **AI-driven innovations in the Hubli-Dharwad BRT system have significantly improved public transport efficiency, commuter satisfaction, and safety**. The findings suggest that BRTS is seen as a reliable and modern mode of urban mobility, especially by students, working professionals, and low-to-middle-income populations. The integration of

technologies such as real-time tracking, predictive maintenance, automated fare collection, and smart surveillance has elevated commuter experience and operational efficiency. However, disparities in awareness and perceptions across gender, income, and occupation suggest the need for more inclusive digital literacy efforts. Furthermore, the relatively modest scores on aspects like system expansion and AI innovation point to areas requiring strategic investments and planning. Going forward, enhancing commuter education, expanding route networks, and reinforcing safety infrastructure will be essential to fully harness the transformative potential of AI in public transport. Ultimately, the Hubli-Dharwad BRTS can serve as a replicable model for Tier-2 cities striving for sustainable and intelligent urban transit solutions.

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