International Journal on Engineering Technology and Infrastructure Development (InJET-InDev)
www.lec.edu.np/journal
Volume 2, Issue no 1., Page 193-207
Received Date: 3/5/2025
Revised Date: 6/23/2025
Accepted Date: 6/25/2025
ISSN: 3021-999X (Print)

Reassessing the Bus Priority Lane and Exploring the Feasibility of BRT in Kathmandu

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Abstract

The rapid urbanization of Nepal's cities has brought escalating challenges in managing urban mobility, such as severe traffic congestion, road deterioration, and increased vehicular emissions. Despite initial attempts to introduce a Bus Rapid Transit (BRT) system as a sustainable alternative, Kathmandu's transport initiative launched a bus priority lane in 2023. However, it has been mischaracterized as a BRT system and has failed to achieve its intended objectives of reducing congestion and improved efficiency. This study critically evaluates the feasibility of implementing a true BRT system in Kathmandu, addressing the misconception highlighted by reviewers, and identifies key barriers such as inadequate infrastructure, operational inefficiencies, absence of Intelligent Traffic Systems (ITS), limited lane segregation, low public engagement, and fragmented governance. Utilizing a comparative case study approach, the research draws lessons from successful BRT implementations in Bogota (Colombia), Jakarta (Indonesia), and Ahmedabad (India), as well as failures in Delhi (India) and Dhaka (Bangladesh), to propose tailored solutions. Recommendations include innovative infrastructure designs for narrow roads, establishment of a dedicated transport authority, integration of ITS, and robust public awareness campaigns, aligned with the 2024 BRT Standard's emphasis on gender inclusion, safety, and sustainability. These findings offer actionable insights for policymakers, demonstrating how a well-executed BRT system along Kathmandu's Ring Road could enhance road longevity, traffic efficiency, passenger safety, and overall urban mobility in a developing country context.

Keywords: BRT system, Bus priority lanes, Sustainable transportation, Infrastructural challenges, Operational inefficiencies, Traffic congestion

1. Introduction

Congestion on the road, environmental degradation, and deterioration in road efficiency are some of the major challenges of rapid urban population growth in developing countries that hamper sustainable urban mobility (Barbosa et al., 2021). Kathmandu, which covers 413.69 square kilometers and has a population of 2,041,587 according to the 2021 census, faces these problems acutely. As the city is still expanding, people continue to migrate to the capital for better jobs, education, and living standards (Ishtiaque et al., 2017). This growth places immense pressure on infrastructure, especially public transportation systems, as public transportation is inadequate and often overwhelmed, leading to severe congestion, overburdening of public buses, and extended travel time (Pande et al., 2022). Suburban commuters face the greatest difficulties due to limited and overcrowded public transportation options to access the city for commercial and administrative activities. Roadways are frequently congested, limiting the efficient flow of goods and people, affecting productivity, and lowering quality of life. Timsina et al. (2020) project that these issues will intensify as Kathmandu's population and economic growth continue to grow without adequate, high-capacity public transportation alternatives.

1.1 Kathmandu bus priority lane system

On September 20, 2023, Kathmandu introduced a bus priority lane system along a 13.4-kilometer route from Ratnapark to Suryabinayak. This initiative reserved lanes (marked in red) for bus use during operating hours. While sometimes referred to as "BRT" in local media, it's crucial to clarify that this implementation lacked the most essential elements of a comprehensive BRT system as defined by international standards. The implemented priority lane system featured:

- Painted lanes designated for buses
- Conventional buses rather than specialized BRT vehicles
- On-board fare collection
- Basic bus stops rather than enclosed stations
- Limited integration with other transport modes
- No advanced intelligent transportation system

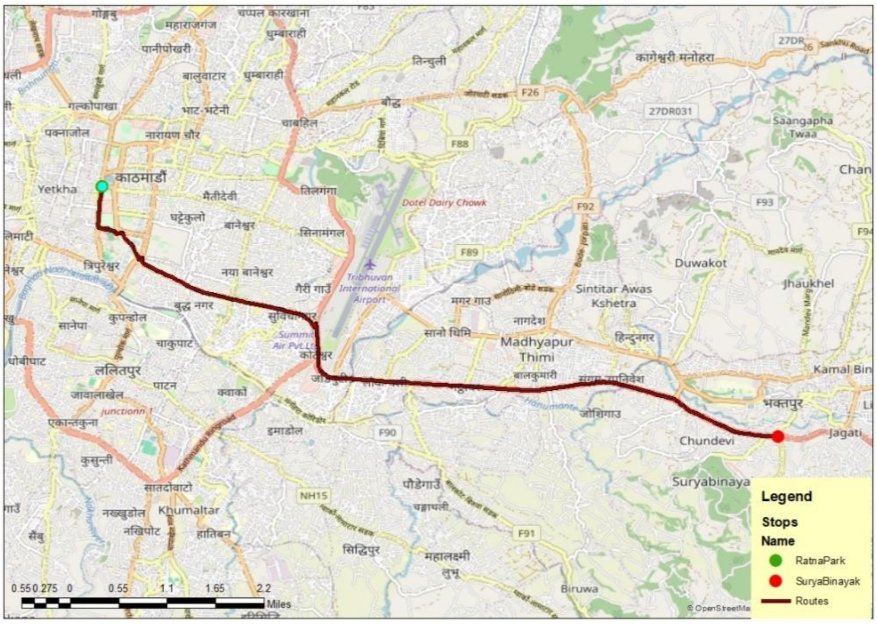

Figure 1. Bus priority lane route in Kathmandu

This implementation represents what transport planners would classify as a bus priority measure rather than a comprehensive BRT system. While it was a step toward improving public transportation in Kathmandu, its limited scope resulted in limited improvements in travel time and reliability.

1.2 BRT systems vs. bus priority lanes

BRT is a high-capacity bus-based transit system with essential features such as a dedicated right of way, busway alignment, off-board fare collection, intersection treatments, and platform-level boarding to deliver fast, reliable, high-quality services at low cost with metro-level capacities (Cervero, 2013). This approach was first introduced in Curitiba, Brazil, in 1974 and has since been adopted by cities like Bogota and Jakarta to reduce congestion, improve travel times, and promote sustainable urban expansion (Jauregui-Fung, 2022; Ramirez et al., 2021).

According to the Institute for Transportation and Development Policy (ITDP), (2024) a comprehensive BRT system is characterized by several essential features that distinguish it from conventional bus services or simple priority lanes. A true BRT system includes several key features: dedicated and physically separated right-of-way, optimized busway alignment to avoid traffic conflicts, off-board fare collection to expedite boarding, intersection treatments to minimize bus delays, and platform-level boarding to enhance accessibility and reduce boarding times. Additionally, advanced BRT systems incorporate features such as integrated networks of routes and corridors, enclosed stations, pre-board fare verification, and intelligent transportation systems for operational management (ITDP, 2024).

The BRT Standard, maintained by ITDP, provides a scoring system to evaluate BRT implementations worldwide, classifying them as gold, silver, or bronze standards based on their adherence to these defining features. This standard emphasizes that BRT is not merely about dedicated lanes but encompasses a comprehensive approach to public transportation that includes infrastructure, vehicles, operations, and customer service elements working together as an integrated system.

The use of the BRT system can also reduce toxins such as CO, benzene, and fine particulates (PM 2.5) by up to 70% (Baghini et al., 2014). The implementation of electric buses in BRT on high-capacity corridors will further lessen the daily emissions by 7500 tons, with a massive drop in emissions of more than 16000 tons per year (Bhattarai & Adhikari, 2024). Expanding these environmental advantages, high-occupancy buses used in BRT systems emit much fewer emissions per passenger than low-occupancy vehicles such as cars and motorbikes. For instance, a fully occupied car emits 1.8 metric tons of CO_2 per year per passenger, while a motorbike produces 1.3 times higher emissions (EPA, 2024; Bradly & Associates, 2019). However, at efficient speeds of 40 km/hour, BRT buses have six times the fuel efficiency per passenger kilometer as private cars (Welle et al., 2023). Furthermore, the BRT system could improve air quality by reducing dependency on private vehicles.

In contrast, bus priority lanes, such as those recently implemented in Kathmandu, represent a more limited intervention that primarily involves allocating road space for bus use without incorporating most of the other essential BRT elements. While bus priority lanes can improve bus speeds and reliability to some extent, they lack the transformative potential of comprehensive BRT systems in terms of capacity, speed, reliability, and passenger experience.

1.3 Objective of the study

Even with clear benefits of BRT system, Kathmandu's efforts for implementation of BRT system, are suffering from insufficient infrastructure and operational and institutional inefficiencies. These issues show that developing countries' institutional capacities and development of necessary infrastructure normally lag the requirements of rapid urbanization. Though there exist numerous studies on successful BRT implementations worldwide, limited studies have focused on its scope and its unique challenges that may arise in the context of Nepal. The issue of infrastructure and governance has also proven to be a barrier to the success of these systems. So, there is a pressing need for research in Nepal that critically examines the institutional, technical, and operational shortcomings that have impeded the success of bus priority lane project.

To address these challenges, this paper conducts a comprehensive review of Kathmandu's bus priority lane system, drawing lessons from international case studies of BRT implementations in India, Indonesia, Colombia, and other developing nations. This study employs a comparative analysis of Kathmandu's bus priority lane to diagnose its operational deficiencies, thereby offering a strategic framework and actionable recommendations to preempt these challenges in the future implementation of a robust BRT system. The scope of this study is focused on evaluating the structural, operational, and governance challenges that have hindered the successful implementation of Kathmandu's bus priority lane system. Although the research primarily draws upon information collected from peer-reviewed journals, reports of government, and case studies, some limitations must be acknowledged. Due to the unavailability of real-time operational data and interviews with key stakeholders, the study could not encompass all the variables affecting system performance. Nevertheless, these findings offer sustainable urban mobility in developing countries, and they also provide some recommendations that could help in policy reform and infrastructure development in similar cases.

In conclusion, this analysis demonstrates that Nepal's initial step toward a BRT system faltered due to critical deficiencies in infrastructure, governance, planning, and technology, proving that these fundamental gaps must be addressed before any large-scale transit project can succeed. By drawing on international best practices and addressing the identified shortcomings, Kathmandu has the potential to revitalize its urban mobility landscape. The lessons of this research are important for the future of public transport in Kathmandu and other cities facing similar challenges in sustainable development.

2. Literature Review

This section reviews successful and unsuccessful BRT system to better understand how Kathmandu's transit experience compares globally and identifies challenges specific to developing countries.

2.1 Global success and failures of BRT systems

The BRT systems have been adopted worldwide as an efficient, cost-effective solution to urban traffic congestion and public transportation challenges since 1974 (Cervero, 2013). Notable successes include TransMilenio in Bogota (Colombia) and TransJakarta in Jakarta (Indonesia) highlighting how meticulously designed BRT networks can deliver significant benefits, including reduced traffic congestion, shorter travel times, and improved air quality (Lu, 2022; Hensher & Mulley, 2016). The BRT systems have also demonstrated the critical importance of well-planned infrastructure, including exclusive bus lanes, efficient station design, and integrated ticketing systems to ensure operational efficiency and public satisfaction (Vecino-Ortiz & Hyder, 2015). However, not all BRT systems implemented have resulted in global success. Delhi, for example, faced several challenges like poor planning, inadequate infrastructure, and low public acceptance, resulting in suboptimal performance. The Times of India (2015) discussed statements by Manish Sisodia, then Deputy Chief Minister of Delhi, who attributed the failure of the BRT project to poor planning and a lack of integration with existing infrastructure. Sisodia emphasized that, although a well-implemented mass rapid transport system could effectively provide last-mile connectivity, the BRT project did not alleviate congestion as intended. The study conducted by Tiwari & Jain (2012) also identified the barriers that hindered safe access to BRT stations and emphasized the need for improved infrastructure to enhance user safety and convenience. Thus, these contrasting experiences show the success of BRT systems hinges on several critical factors, including dedicated infrastructure, efficient traffic management, and public acceptance.

2.2 Challenges in developing countries: lessons for Nepal

The BRT systems in developing countries often encounter a lot of unique challenges as compared to those in developed nations, such as narrow roads, informal transport networks, and insufficient infrastructure investments (Yanar, 2023; Medeiros et al., 2023; Chabariko et al., 2017). Many peer-reviewed studies conducted worldwide have identified key barriers that impede the success of BRT systems, including competition from informal transport modes, limited government funding, and poor traffic management. Dhaka's BRT, for example, has suffered significant delays due to a lack of coordinated government action and the dominance of informal transport systems, including minibuses and autorickshaws, that attract many daily commuters (Mohin & Rehman, 2018). Also, the study by Teko (2017) claims the BRT system implemented in Accra, Ghana, faced significant institutional hurdles, notably the absence of a cross-jurisdictional authority to oversee urban passenger transport and a lack of ownership arrangements for existing bus operators. Adeel et al. (2016) further claimed the current transport policies (not necessarily BRT) often overlooked marginalized groups, including women and disabled individuals. Similarly, Oluwaseun (2021) examined the operational challenges encountered by BRT in Lagos, Nigeria, and highlighted several key issues impeding the effectiveness and efficiency of the BRT services, including infrastructure limitations, traffic congestion, and financial constraints. However, many peer studies have repeatedly discussed the rise of informal public transport systems in developing countries and critiqued the BRT systems as a solution (Yanar, 2023; Medeiros et al., 2023; Chabariko et al., 2017). So, despite the challenges mentioned, these challenges can also be overcome. The Indian City, Ahmedabad, for example, faced resistance when Ahmedabad's Janmarg BRT was introduced due to poor integration with other transport modes. However, through sustained government investment in dedicated bus corridors and better public engagement strategies, the system eventually encouraged widespread acceptance and ridership, offering valuable lessons for developing countries like Nepal (Smart City Council, 2020). These studies therefore highlight that while developing counties do face challenges, targeted policy interventions, infrastructure improvements, and public outreach can transform underperforming BRT systems into successful models of urban transportation.

2.3 Technological integration and public engagement

Technological innovation provides an important improvement in the efficiency and reliability of BRT systems. Dar es Salaam (Tanzania) has significantly enhanced BRT performance by integrating Intelligent Traffic Systems (ITS), which prioritize BRT vehicles at intersections and manage traffic flow in real time, proving crucial for cities like Dar es Salaam (Trubia & Severino, 2020). The ITS technology allows for real-time monitoring and adjustments of traffic to reduce delays and prioritizes the buses, thus improving operational efficiency and reducing travel times for passengers. Therefore, the integration of ITS in Nepal's future BRT initiatives could be critical for enhancing the system's performance and public acceptance. Similarly, another key factor is public engagement, which has an important role in the success of the BRT system, as highlighted by examples from Nigeria where public trust resulted in greater ridership (Litman, 2018). The study by Litman (2018) indicates that gaining public approval early on is essential for building ridership, and this approval often correlates with system performance during initial operation and the effectiveness of its marketing strategies. The government also engaged with the public through media campaigns and community outreach to show the benefits of using BRT over informal transportation. Nepal could also adopt similar strategies to increase the public buy-in for future

BRT projects and thus ensure that the system is a reliable and desirable alternative to private and informal transport, thus ensuring the success of BRT projects.

These global experiences emphasize that along with infrastructure, dedication, institutional alignment and public trust are also equally important to improve transit systems, especially in contexts of developing cities like Kathmandu.

3. Methodology

Building on insights from global BRT systems, this research uses qualitative review methodology for comparing Nepal's transportation system with cities like Bogota, Jakarta, and Ahmedabad to uncover insight that can inform potential improvements by studying critical factors influencing success and failure in diverse socio-economic

contexts. As in Figure 2, secondary data from peer-reviewed articles and official reports from organizations like the World Bank, UN, and ITDP are used, emphasizing infrastructural sufficiency, operational efficiency, and public perception and engagement. The research provides detailed insights into the shortcomings and opportunities for viable alternative, BRT system in Nepal, highlighting the challenges faced and providing strategic recommendations to enhance the effectiveness of the system.

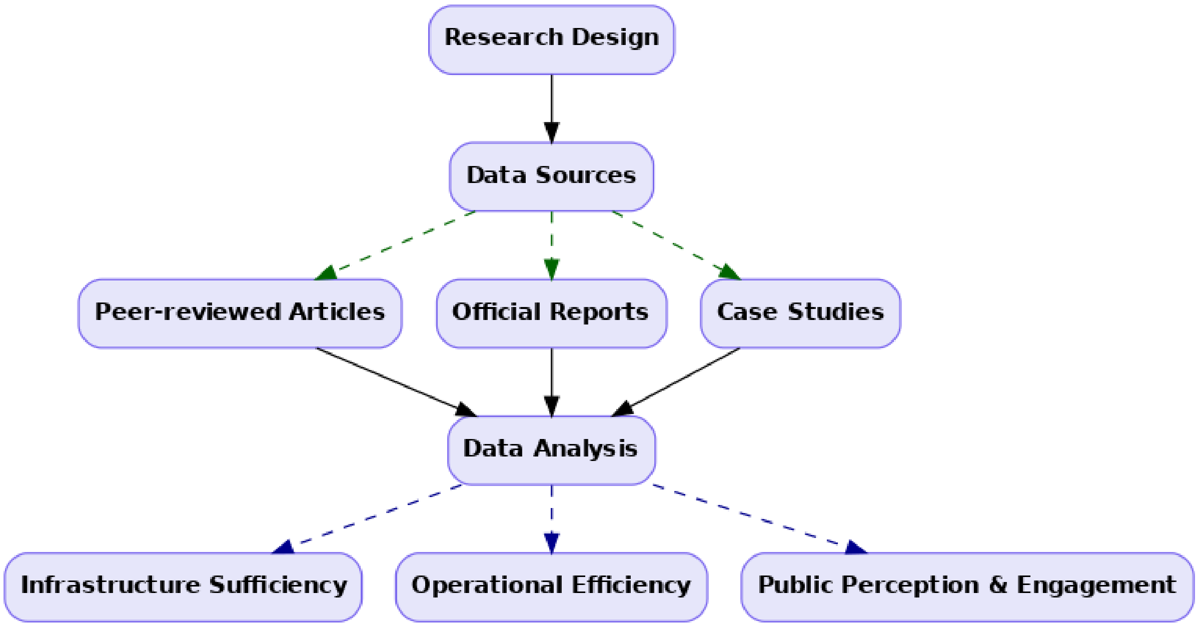

Figure 2. Flowchart of the research methodology adopted

4. Lessons from Comparative Case Studies

To contextualize the experience of Kathmandu, this section presents comparative case studies of successful BRT systems. The TransMilenio of Bogata and TransJakarta of Jakarta provide valuable lessons in terms of planning of infrastructure and operational management.

4.1 Transmilenio

The TransMilenio BRT system, inaugurated on December 4, 2000, in Bogota, Colombia, stands as a landmark urban transit project that serves as a lesson for developing countries like Nepal to achieve sustainable transportation solutions. The system, designed to tackle Bogota's urban transport challenges due to exponential population growth, emphasizes operational efficiency, environmental sustainability, and financial viability using high-capacity buses with large passenger volumes, centralized fare collection, access control, and real-time operations monitoring supported by GPS and two-way communication systems (Perdomo et al., 2007). The key features and system design of the TransMilenio BRT, as summarized by the World Bank (2009), include several innovative elements aimed at accommodating high passenger volumes and enhancing operational efficiency. The features are listed below:

Structural Features:

Design and capacity: The BRT system includes exclusive bus lanes, high-capacity buses, and level boarding at stations to facilitate quick access. The stations are strategically placed every 500 meters (ITDP, 2023).

Operational model: The system comprises a trunk-and-feeder route network with 11 central trunk corridors, with over 113 km of dedicated busways. The trunk corridors are designed for articulated and bi-articulated buses, which

can carry between 160 and 270 passengers. The buses operate with high-frequency schedules and often depart at intervals as short as 90 seconds during peak hours. As of 2023, the system had approximately 145 stations spread across the city, with new lines continually under construction to expand coverage (ITDP, 2023).

Technological integration: The system also utilizes advanced technologies for ticketing and operational control to enhance efficiency. The passengers pay their fares using a smart card system before boarding buses, which significantly decreases the boarding time compared to traditional in-bus fare collection systems (ITDP, 2023).

Performance Metrics:

Ridership: This system serves more than 1.5 million passengers daily, with a designed capacity to handle as many as 5 million people. Nine percent of TransMilenio passengers have now shifted to public transportation (Center for Public Impact, 2016).

Travel efficiency: The average trip times have decreased by 32% with travel speeds increasing from 12-18 km/hr to approximately 26.7 km/hr.

Safety improvements: The traffic fatalities in Bogota have dropped by 92% and injuries by 75%, thus contributing to a safer urban environment (Centre for Public Impact, 2016).

Socio-Economic and Environmental aspects:

The project has also significantly improved urban mobility in Bogotá, especially for low- and middle-income residents who had to rely on unsafe, inefficient, and highly polluting informal and unregulated bus services. TransMilenio, after implementation, has offered regulated, reliable, and high-capacity transit solutions, thus reshaped the city's transportation dynamics and provided access to education, healthcare, and employment opportunities for millions (ITDP, 2023). The project operates under the Public-Private Partnership (PPP) model and is financially sustainable without the need for public operating subsidies. The project has reduced travel times by up to 32%, improving productivity and enabling residents to engage more effectively with economic opportunities (World Bank, 2009). The studies conducted by Bocarejo et al. (2013) also indicated a significant increase in real estate prices near BRT corridors, particularly within 500 meters of the stations rising as high as 15%, also reveals the project had broader economic implications, especially for transit-oriented development. The system was also projected to reduce carbon emissions by 15-25 million metric tons over its first 30 years of operations, thus aligning with the reported fuel saving of approximately 47% (ESMAP, 2010). The claims have also been supported by the reports from (Infobae, 2023) and the study conducted by Pérez et al., (2024).

Challenges and operational criticisms:

TransMilenio, though successful has encountered several operational challenges since its operation, that offer critical insights for other countries, including Nepal:

Overcrowding: TransMilenio faces a significant challenge due to severe overcrowding, which has doubled its capacity during peak hours. A study on public transport systems by Li and Hensher (2012) in Australian cities highlighted that overcrowding significantly impacted passenger satisfaction which is evident in TransMilenio as the system's insufficient expansion has led to long waiting times and frequent service delays, affecting passenger satisfaction and willingness to pay for improved condition.

Infrastructure Maintenance and Operational Costs: BRT's infrastructure maintenance is challenging due to wear and tear on dedicated bus lanes, requiring costly repairs (Krüger et al., 2021). Fare hikes, primarily for fare collection, make the system less affordable for low-income passengers, emphasizing the need for diversification for long-term sustainability.

4.2 Transjakarta

While TransMilenio emphasizes centralized control and mainitaining corridor efficiency, TransJakarta highlights the importance of a multimodal integration system. The BRT system, started on 15 January 2004 A.D. in Jakarta, Indonesia is the world's longest Bus Rapid Transit system spanning over 250 kilometers of exclusive lane throughout the Jakarta Metropolitain area which operates about 4300 buses (Jauregui-Fung, 2022). It was one of the first BRT systems in southeast Asia designed to alleviate Jakarta's ongoing traffic congestion, reduce air pollution, and provide cost-effective and affordable public transport solutions. With its dense population, rapid motorization and limited public transport infrastructures, TransJakarta's urban setting has made TransJakarta's BRT system a crucial case studies for developing countries like Nepal for implementing BRT system. TransJakarta resembles following key points:

Structural Features:

Design and Capacity: The TransJakarta BRT has dedicated lanes to improve the city's mobility and reduce traffic congestion with a capacity of 85 passengers and stations at every 500 to 1000 meters to cater to the public transportation needs of the city (Kreindler et al., 2023).

Operational Model: TransJakarta is divided into trunk, liner, and feeder lines. The trunk network covers over 250 kilometers of busways with 13 corridors and feeder lines connecting small areas (Kusumaningkatma & Xie, 2020). During peak hours, buses operate at short intervals with some running 24 hours a day. TransJakarta serves over 244 stations across Jakarta, with plans for further expansions to improve coverage and accessibility. Transjakarta also runs late-night services known as "Malam-Hari" or "Amari" buses on major corridors from 10 pm to 5 am (Jakarta time, 2022).

Technological Integrations: TransJakarta is using an electronic ticketing system called JakLingo, allowing passengers to top up their cards and swipe before boarding buses, reducing waiting time. The system also uses real-time GPS tracking called "Moovit" to track the bus positions for optimizing routes and adjusting frequencies (Institute for Transportation & Development Policy, 2021).

Performance Metrics:

Ridership: TransJakarta serves a metropolitan city of about ten million residents facilitating an average daily ridership of 1 million passengers, and an annual ridership of 280 million passengers as of 2023. It is designed to fit more users as the system grows and connects with other public transport alternatives (ANTARA News, 2024).

Travel Efficiency: TransJakarta has significantly increased Jakarta's traffic speed from 10-15km/hour to 20-30 km/hour in many corridors, lowering travel time by 20-30% for commuters using BRT. As per Jakarta's spatial plan, the administration further aims to increase the average speed of vehicles throughout the city to 35 km/hour by 2030. The dedicated bus lanes have helped in decreasing traffic congestion, making public transport more efficient and dependable (Sidiq, 2019).

Environmental impact: Jakarta's rapid motorization has significantly contributed to reducing emissions and controlling air pollution. Transjakarta lowered travel time by ten minutes for each passenger trip and reduced

greenhouse gas emissions by approximately 0.15 tons per passenger annually in 2012 (Jauregui-Fung, 2022). The study by Jauregui-Fung (2022), also concluded that the implementation of TransJakarta has led to a reduction in air pollution by as much as 20%, significantly improving the air quality in the Jakarta Metropolitan area. Full electrification of BRT is expected by 2030 which further will reduce carbon dioxide (CO_2) emissions by 30% (Southeast Asia Infrastructure, 2023).

Socio-Economic Aspect :

TransJakarta was designed to address a major issue of TransJakarta by offering an alternative to private cars. Between 2004 to 2023, the number of daily TransJakarta users has increased from 60,000 to over one million, showing its growing acceptance as a public transport option (ITDP, 2021). The system has also led to a modest reduction in traffic congestion, especially in corridors with several BRT lanes. The shift towards mass transit indirectly improves road life and urban infrastructure by reducing wear and tear.

TransJakarta is highly affordable with an average fare of IDR 3,500, making it accessible to a generous portion of Jakarta's population, including low-income residents (Kusumaningkatma & Xie, 2020). The system provides a more predictable and affordable mode of transportation compared to informal public transport options. The development of TransJakarta has created thousands of jobs, including bus operators, maintenance personnel, security, and administrative roles. The project has also spurred investment in transit-oriented development boosting the city's economy.

Challenges and Operational Criticism:

Lane Violation and Enforcement Issues: TransJakarta has faced substantial operating issues because of frequent lane violations by private vehicles. Although TransJakarta buses use exclusive bus lanes, these lanes are frequently breached by motorbikes, cars, and other vehicles, particularly during peak hours. This has led to slower bus speeds and reduced system efficiency. The difficulty of enforcement highlights the importance of having strong legal frameworks and traffic management strategies to ensure that BRT lanes remain exclusive to public buses (Safitri, 2020).

Overcrowding and Inadequate Expansion: TransJakarta has suffered overcrowding issues, especially during peak hours. Despite being designed to reduce congestion, the growing demand for public transit has resulted in packed buses and stations. The system was initially designed for fewer passengers, and while expansion has been made, they have not been keeping pace with the growing demand, causing discomfort and dissatisfaction among users (Budiman et al., 2024). This issue is relevant for Nepal, as anticipating demand and correctly scaling infrastructure would be vital to the long-term success of the BRT system. Adequate planning for future expansions and real-time monitoring of passenger levels will help address these difficulties.

Fare Evasion and Financial Sustainability: Another issue that TransJakarta has faced is fare evasion, which hinders the financial sustainability of the system. Despite the introduction of smart cards and turnstile systems, fare evasion is still an issue, especially at bus terminals where enforcement is slack (Franco Jauregui-Fung, 2022). This has challenges for the system's financial sustainability, which relies heavily on fare revenues. Implementing efficient fare collecting and enforcement mechanisms is critical for Nepal's BRT to ensure operational efficiency and financial viability.

Table 1. Comparison between Trans Milenio and TransJakarta

Aspect	Trans Milenio	TransJakarta
Location	Bogota, Colombia	Jakarta, Indonesia
Launched Date	4 Dec, 2000	15 Jan, 2004
Network Length	113 km of dedicated busways	Over 250km of exclusive lanes
Fleet Size	1,319 bi-articulated buses 602 articulated buses 948 feeder buses	4300 buses
Capacity per bus	Articulated buses: 160 passengers Bi-articulated buses: 270 buses	85 passengers per bus
Feeder Routes	71 routes	155 routes
Daily Ridership	1 million passengers	1.5 million passengers
Station Frequency	Every 500 meters	Every 500-1000 meters
No. of Stations	Approximately 145 stations	244 stations with ongoing expansions
Fare System	Smart Card Systems for off-board fare collection	JakLingo electric ticketing with top-up cards
Technological Integration	GPS tracking, centralized fare collection, and real-time monitoring	Moovit GPS tracking, real-time route optimization
Average Time Speed	Increased to 26.7 km/hour	Increased to 20-30km/hour: plan to increase to 35 km/hour by 2030
Travel Time Reduction	Average trip time decreased by 32%	Travel time reduced by 20-30%
Environmental Impact	Reduced CO2 emission by 15-25 million metric tons over 30 years	Aims to be fully electrified by 2030, reducing CO2 by 30%
Socio-economic Impact	Increased property values near the BRT corridor by up to 15%	Affordable fare supports transit-oriented urban development
Challenges	Overcrowding, Infrastructure maintenance	Lane violations, overcrowding, fare evasion
Lessons for Nepal	Scalability, transit-oriented development	Multimodal integration, sustainable fleet development, inclusivity

These comparative insights present both potential and challenges for BRT systems. Similar to Kathmandu, the diverse socio-economic communities of Bogota and Jakarta rely heavily on affordable and efficient public transportation. Thus, it has consistently been demonstrated that the BRT system is a viable alternative to solve the growing problems of transportation in expanding cities like Kathmandu. TransJakarta's success in integrating with Jakarta's commuter trains and other transportation systems emphasizes the need to develop a unified public transportation network. Nepal can collaborate with the Federation of Nepali National Transport Entrepreneurs (FNNTE), and ride-sharing platforms such as Pathao, and Indrive to reduce the congestion of traffic and increase dependency on public vehicles. Concurrently, TransMilenio's impact on real estate and urban development suggests that integrating BRT planning with land use policies can lead to long-term urban transformation. TransMilenio's reliance on fares as the primary source of funding has led to affordability issues suggesting a mixed funding model for Nepal, including government subsidies and private investments, making it affordable to its users. TransJakarta's shift toward complete electrification highlights the viability of adopting sustainable public transport solutions in urban areas, commencing Nepal for hybrid or electric buses, to meet evolving global standards. Lessons from TransJakarta's inclusive service model underscore a strategic imperative for Nepal: to ensure long-term viability, any future BRT system must be built upon a foundation of universal accessibility to effectively serve all segments of the population.

5. Findings, Discussion, and Engineering Recommendations

The expressway bus system in Kathmandu has been significantly limited in its effectiveness, failing to deliver the anticipated benefits of increased traffic efficiency, enhanced passenger safety, and reduced environmental pollution (Wang et al., 2023). This outcome is not an isolated incident but rather the result of a complex interplay of deep-seated infrastructural and operational deficiencies. The failure to address these core issues, which are common in rapidly urbanizing developing cities, has rendered the current bus priority lane largely ineffective.

The constellation of challenges facing Kathmandu is visually encapsulated in Figure 3, which illustrates the interconnected nature of the problems that undermine the public transport system. This analysis uses the challenges identified in Figure 3 as a framework to diagnose the specific issues in Kathmandu's context before proposing tailored engineering and policy recommendations.

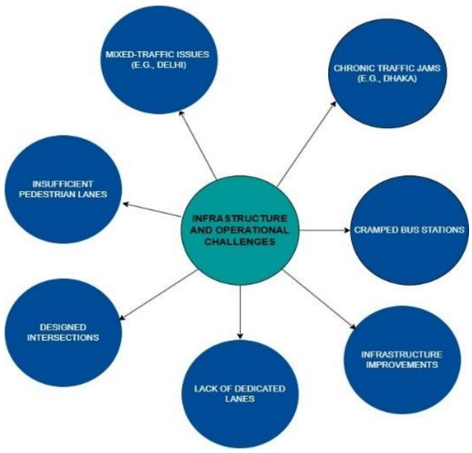

Figure 3. Infrastructural and Operational Challenges in Nepal

5.1 Diagnosing kathmandu's core deficiencies

As outlined in Figure 3, the predicament in Kathmandu stems from several critical failures, which can be analyzed through the lens of the city's unique urban characteristics.

- **The Vicious Cycle of Mixed Traffic and Porous Lanes:**

  Central to the system's failure is the lack of dedicated lanes with robust physical segregation. Japan International Agency (2019) highlights the Ring Road with right of way up to 62m in their detailed report, which can provide space for BRT, but the inner arterials, some of which are as narrow as 5-7 meters cannot support full segregation (The painted priority lane has proven insufficient to deter encroachment in Kathmandu's chaotic traffic environment, which is dominated by nearly 1.5 million motorcycles which is almost 80% of the registered vehicles (Department of Transport Management, 2022). This creates severe mixed-traffic issues, mirroring the challenges that led to the eventual dismantling of Delhi's BRT corridor (James, 2020). The constant weaving of two-wheelers and other vehicles into the bus lane negates any potential speed or reliability advantage, perpetuating the chronic traffic jams seen in cities like Dhaka (Mohsin & Rahman, 2018). Higher trip density in peak hours, due to radial land use patterns, forces thousands of suburban commuters into the same few corridors. This problem is exacerbated by Kathmandu's road network dichotomy: while the 8-lane Ring Road has the physical width for segregation, the narrow arterial roads of the city core do not, making a single-solution approach unfeasible.

- **Inadequate Nodal Infrastructure and Pedestrian Hostility**:

  The operational efficiency of a transit system is critically dependent on its nodes—stations and intersections. In Kathmandu, bus stops are little more than designated curbsides, leading to cramped bus stations that are unsafe and inefficient, forcing buses to merge back into congested traffic. Furthermore, the lack of properly designed intersections with signal priority for buses means that any time gained on a corridor is lost while waiting at junctions. Compounding this is the severe lack of sufficient pedestrian lanes and safe crossings. For a BRT system to be a viable alternative, potential users must be able to access stations safely and conveniently. In a city where commuters are expected to risk crossing multiple lanes of high-speed traffic, the barrier to switching from a private vehicle to public transport remains insurmountably high (Panday & Adhikari, 2020). This lack of user-centric infrastructure improvements has been a critical oversight.

These deficiencies collectively ensure that the current system cannot offer a compelling value proposition over private transport, thereby failing to attract the modal shift necessary to alleviate congestion or reduce road degradation. Unlike hyper-dense cities like Jakarta (approx. 15,900 people/sq. km), Kathmandu’s high commuter trip density stems from rapid, unplanned peri-urban sprawl into a core with a limited and constrained road network (Ishtiaque et al., 2017). Although Kathmandu's population density (approx. 5,169 people/sq.km) is lower than Jakarta, but is concentrated along bottleneck corridors like Kalanki and Koteshwor. Drawing lessons from successful systems, it is clear that addressing these foundational challenges requires a targeted and holistic approach.

5.2 Strategic eecommendations for a viable Kathmandu BRT system

To overcome the multifaceted challenges diagnosed in the preceding section, a holistic strategy comprising specific infrastructural, technological, and operational interventions, as visually summarized in Figure 4, is essential. These recommendations, rooted in global best practices but tailored to Kathmandu's unique urban fabric, provide a clear roadmap for developing a true Bus Rapid Transit system.

Figure 4. Recommendations for Improvement of BRT in Nepal

- **Dedicated Corridors and Road Infrastructure Upgrades:** The foundational step, directly addressing the failure of the painted lanes, is the establishment of Dedicated BRT Corridors with Segregated Lanes. This requires the installation of physical barriers (e.g., concrete curbs) to guarantee an exclusive right-of-way, particularly along the 27-kilometer Ring Road, to prevent the encroachment by motorcycles that crippled the previous initiative. Pedestrians access is also hindered by lack of crossing on roads like Kuleshwor-Kalanki which needs to be improved. This corridor development must be coupled with a comprehensive Road Infrastructure Upgrade. This includes the reinforcement of pavements to withstand the higher axle loads of high-capacity buses and, in the long term, considering grade separation at critical, high-conflict intersections to maintain uninterrupted flow and enhance safety (Peden et al., 2002).
- **High-Capacity Stations and Bus Fleet Design:** Success is also contingent on developing High-capacity bus stations and Terminals that provide a safe, efficient, and dignified user experience. These must be purpose-built multi-platform stations featuring critical accessibility features (e.g., ramps, tactile paving) and off-board fare collection to ensure rapid boarding for all users, including those with disabilities. Integrating Advanced Passenger Information Systems (PIS), providing real-time arrival data, is crucial for building public trust and competing with the perceived predictability of private vehicles. These corridors must be serviced by a modern Bus Fleet with clear Design and Specifications, prioritizing Low Emission or Electric Buses to maximize environmental co-benefits and align with global sustainability goals (Kusumaningkatma & Xie, 2020).
- **ITS Integration for Network-Wide Efficiency:** For network-wide efficiency and to overcome the challenge of narrow roads, ITS integration is paramount. On the segregated Ring Road, a real-time monitoring system will optimize bus dispatch and headway management. Critically, on the narrower arterial feeder routes like Tripureshwor, Baneshwor and Putali Sadak (width<10m), where full segregation is unfeasible, Traffic Signal Priority (TSP) becomes the key technological tool. TSP allows approaching buses to wirelessly request green light extensions from traffic signals, enabling them to navigate congested junctions efficiently without requiring full physical segregation, a solution perfectly suited to Kathmandu's road width constraints (Wang et al., 2023).
- **The Overarching Need for Institutional Reform:** While the technical recommendations outlined in Figure 4 provide the necessary physical blueprint, their success is entirely conditional upon a profound institutional overhaul. These hardware components require robust "software" to function. This necessitates the establishment of a single Kathmandu Valley Transport Authority (KVTA) with the legal and financial authority to plan, regulate, and manage all public transport operations. Furthermore, a formal route franchising model is required to integrate existing private operators into a coherent feeder network, and a unified fare system is essential for seamless transfers. Without this robust governance framework, the 'hardware' of new lanes and buses will fail to create a coherent, reliable, and financially sustainable system (Cervero, 2013).

6. Conclusion

The failure of the recent express busway serves as a critical lesson: superficial interventions cannot solve deep-seated urban mobility challenges. This study demonstrates that the path to effective public transport in Kathmandu is obstructed not by a failure to holistically address the city’s unique infrastructural deficiencies, operational chaos, and fragmented governance. The successes in Bogotá and Jakarta, and the struggles in Delhi and Dhaka, reveal that a successful BRT is an integrated ecosystem, not just a segregated lane.

For Kathmandu, this research concludes that a sustainable path forward demands a nuanced, two-pronged strategy. First, leveraging the city's primary asset—the wide Ring Road—to build a true, physically segregated BRT "spine" can serve as the backbone of a new transit network. This must be complemented by a "BRT-Lite" approach for the narrow inner-city corridors, relying on technology like Transit Signal Priority rather than unfeasible land acquisition. Second, and more critically, this physical infrastructure must be supported by a profound change in institutional infrastructure. The establishment of a unified Kathmandu Valley Transport Authority is non-negotiable; it is the only mechanism capable of dismantling regulatory silos, integrating informal transport operators into a formal feeder network, and deploying the unified ticketing and information systems that modern commuters expect.

Ultimately, this study's findings advocate for moving beyond piecemeal efforts. Implementing a successful BRT system in Kathmandu requires significant investment, robust political commitment, and a design philosophy that is tailored to the city's specific realities—its road network dichotomy, its two-wheeler-dominated traffic, and its existing transport economy. By embracing this tailored and integrated approach, Kathmandu has the potential to transform its gridlocked streets into corridors of efficient, equitable, and sustainable mobility for its growing population.

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