

Governing Electric Three Wheelers for Last Mile Mobility in South Asian Secondary Cities

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Case Report

Keywords: Electric Three-Wheeler, Urban Mobility, Last-Mile Solutions, Paratransit Governance, South Asia, Secondary City

Posted Date: October 14th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10915888/v1>

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Additional Declarations: No competing interests reported.

Abstract

Rapid urbanization in South Asian secondary cities has created a growing mobility gap that formal public transport has failed to fill. Because of poor planning, electric three-wheelers (E-3Ws), such as e-rickshaws, easy bikes, and electric tuk-tuks, have naturally proliferated to meet this demand in Bangladesh, India, and Sri Lanka. However, their rapid proliferation has raised an important question: are these vehicles a problem for the city or a useful last-mile solution? This study tries to answer this question using a mixed-methods approach across four secondary cities: Narayanganj, Gazipur, Ludhiana, and Kandy. It combines primary field data from the two Bangladeshi cities with a secondary review of the Indian and Sri Lankan cities, together with a comparison of their rules and governance systems. The results show that short trips under five kilometers make up most daily travel (over 80% of all trips in each city). E-3Ws serve many more of these short trips than formal buses and can reach small local streets that buses cannot, as buses directly cover only about 3–16% of the total road length. They also run at a much lower cost than other modes, produce no tailpipe emissions, and 5–7 times more preferred by women users. Even so, these benefits are not fully used because governments often treat E-3Ws as a problem rather than a mode to integrate. This study argues that turning E-3Ws into a sustainable last-mile solution is mainly an institutional challenge, and suggests a flexible, tiered policy framework suitable for different South Asian cities.

1 Introduction

Rapid urbanization across the Global South has placed unprecedented pressure on urban transport systems, especially in low- and middle-income countries where infrastructure expansion has failed to keep pace with population growth. Cities in South Asia are experiencing accelerated demographic expansion, rising travel demand, and increasing spatial dispersion of urban activities, all of which intensify the need for affordable, reliable, and accessible mobility options [1], [2]. However, the dominant response, reliance on formal, high-capacity public transport systems such as buses and rail, has largely failed to meet this demand [3], [4], [5]. In most low-income South Asian cities, formalized public transport systems suffer from low spatial coverage [6], [4], frequency [7], [8], and last-mile connectivity [9]; they also face a constant lack of funding [10], [11]. Consequently, significant proportions of the urban population and low-income households, women, informal workers, or dwellers in peripheral or dense inner-city areas, remain poorly served [12] [13]. So, the solutions of rich cities, i.e., bike sharing and e-scooters, remain unable to solve these equity issues due to differences in cultural norms, income level, road infrastructure facilities, and safety issues [14]. This systemic failure has created a persistent mobility gap, in which daily travel needs are met neither efficiently nor equitably by conventional transport modes. These have led to greater reliance on informal modes of transport [15] [16], leading to higher levels of traffic congestion and a larger population at risk due to reduced travel safety [17] and increased environmental externalities [18].

In this context of unfulfilled mobility demand, electric three-wheelers (E-3Ws), including e-rickshaws, easy bikes, and electric tuk-tuks, have emerged to bridge the service gaps left by the inadequate formal

public transport system [19] [20]. These vehicles have spread across South Asia without centralized planning or policies, driven by local demand and informal entrepreneurship [21]. Countries such as Bangladesh, India, Nepal, and Sri Lanka have witnessed a rapid rise of E-3Ws over the past decade, especially in secondary cities and crowded urban areas. The attractiveness of E-3Ws is their low capital and operating costs, capability to operate in congested narrow streets, and operation at a door-to-door or near door-to-door level [22]. These characteristics make them especially effective for short-distance trips and first- and last-mile use, where regular public transport systems are inefficient [22]. At the same time, E-3Ws have created large large-scale employment in the informal sector by providing livelihoods to millions of drivers, and that at a low skill threshold [23] [24]. Their electric propulsion also makes them a cleaner alternative than fossil-fuel-based forms of paratransit, at least theoretically [25] [26].

Despite their functional significance, E-3W service providers operate with a lack of regulation, which quickly becomes paradoxical for the urban transportation space. On one hand, E-3Ws are generating significant social and mobility benefits, such as escalation of accessible trips for transport-dependent groups, faster travel times over short distances, creation of employment and income opportunities for drivers, and producing zero tailpipe emissions at the point of use. On the other hand, their unregulated proliferation has caused serious concerns among urban planners and transport authorities. E-3Ws are often linked to worsened traffic congestion [22], [27], reduced travel speeds [28], and increased road safety risks resulting from inadequate vehicle standards and insufficient driver regulation [29]. Even though E-3Ws do not produce direct emissions, there is still debate about their overall environmental impact. The interaction of E-3Ws with mixed traffic flows may potentially impact congestion-induced emissions in multiple ways [28], while many South Asian countries still heavily rely on fossil-fuel-based power generation. Such duality has created an inconsistent and often contradictory policy response throughout the region, alternating between complete prohibition and limited acceptance inside unofficial regulatory structures.

Even though there is an increasing amount of research on electric three-wheelers, the studies have several critical limitations. First, a large amount of the research is confined to the level of an individual city or country research case, restricting the ability to generalize findings over the wide range of urban conditions encountered throughout South Asia [30]. Second, many evaluations are based on stakeholder opinions or descriptive surveys and thus fails to capture the full scenario [31]. There are limited efforts to translate these findings empirically into implementable tiered policy from a practical viewpoint when heterogeneities in cities across the South Asian context is considered [30].

Addressing these gaps, this study further contributes to the literature by: (i) analyzing at regional scale the electric three-wheeler adoption, usage patterns, and regulatory challenges across selected cities in Bangladesh, India, and Sri Lanka; (ii) evaluate the effectiveness of electric three wheelers as last mile nodes based on the spatial, economic, equity and environmental criteria, and (iii) providing an governance foundation for a tiered, context-sensitive policy framework for their sustainable integration into urban transport systems across South Asia.

2 Methodology

This study uses a mixed-methods approach to compare the adoption, usage patterns, policy landscape, and environmental effects of electric three-wheelers (E-3Ws) in selected South Asian cities. The methods include a multi-city case study analysis to discover regional patterns and governance dynamics, integrating the primary empirical data analysis of Bangladeshi cities and a secondary structured review of Indian and Sri Lankan cities. This dual analytical strategy enables the study to reconcile regional applicability with detailed local analysis, thereby facilitating the development of a stratified policy framework for sustainable E-3W integration.

2.1 Study area selection

2.1.1 Comparative case study cities

To investigate regional patterns of electric three-wheeler (E-3W) adoption and regulation in South Asia, this study focuses on four cities: Gazipur and Narayanganj in Bangladesh, Ludhiana in India, and Kandy in Sri Lanka. These cities were selected for their common characteristics as secondary urban centers. Unlike megacities, these areas represent the specific urban typology where E-3W usage is most common, though policy responses are still scattered. Each city has significant industrial or commercial activity along with rapid population growth, leading to high travel demand and increased density that often surpasses infrastructure development. In these contexts, E-3Ws play a key role in daily mobility and first- and last-mile connectivity. By looking at various regulatory setups, from the mostly informal systems in Bangladesh to the more organized ones in India and Sri Lanka, this comparative study helps to identify the common drivers, usage patterns, and institutional challenges that E-3Ws face across the region.

2.2 Data sources and methods

2.2.1 Primary data collection: Gazipur and Narayanganj

Primary data are collected for Gazipur and Narayanganj to capture detailed travel behavior and operational characteristics of E-3Ws.

Travel behavior and modal share data were derived from a comprehensive Household Interview Survey (HIS) conducted on a representative sample of households covering all 27 and 57 wards of Narayanganj City Corporation (NCC) and Gazipur City Corporation (GCC). Survey samples were selected using a stratified random sampling framework, with a total of 2040 and 12,566 households surveyed in NCC and GCC, respectively. Sampling intervals were set at 10-metre intervals, though these were adjusted to accommodate differences in geography, settlement, and population distribution at the ward level. The survey questionnaire captured a comprehensive set of travel behavior variables, including trip purpose and frequency, origin–destination characteristics, mode choice and mode-specific trip share, trip

distance and duration, and first- and last-mile access modes. Passenger car unit (PCU)-based occupancy was estimated from vehicle occupancy surveys conducted on a working day at 29 locations in Narayanganj and 53 locations in Gazipur, covering E-3Ws alongside other public transport modes. Travel speeds under congested conditions were obtained from peak-hour travel time surveys carried out along the main corridors of both cities. Another critical operational parameter, vehicle operating cost (VOC), was determined from vehicle attribute surveys conducted in Narayanganj City. For quantitative environmental assessment, CO₂ emissions were estimated for two vehicle categories, car and bus, using a fuel-consumption-based approach. A mode-specific emission rate (g/veh-km) was derived for each category from its instantaneous fuel consumption rate and average operating speed, converted to CO₂ using a fuel-specific emission coefficient. Emissions were then obtained by multiplying each category's emission rate by its corresponding vehicle-kilometres travelled (veh-km).

Collectively, these datasets provide empirical evidence for rigorous comparisons between E-3Ws and competing transport modes in terms of cost efficiency, space utilization, and operational performance.

2.2.2 Secondary data collection - Ludhiana and Kandy

For Ludhiana and Kandy, a structured review of city-level transport studies was conducted. For instance, the *Comprehensive Mobility Plan for Ludhiana*, prepared by Municipal Corporation Ludhiana, and the *Kandy City Transport Study* conducted by the University of Moratuwa in association with the University of Peradeniya were reviewed. Extracted indicators included trip distance distribution, vehicle occupancy, road network coverage, and regulatory characteristics. While the secondary data do not permit detailed operational or environmental modeling for these cities, they provide sufficient information to compare behavioral patterns, occupancy efficiency, and spatial penetration of E-3Ws within a broader regional context.

2.2.3. Review of regulatory frameworks and policy context

The regulatory context governing E-3W operations in Bangladesh was reviewed through a detailed review of existing and draft policy frameworks. Key documents reviewed included current regulations issued by the Bangladesh Road Transport Authority (BRTA) and the *Draft Electric Motor Vehicle Registration and Operation Guideline (2023)* for Bangladesh. This review identified institutional gaps, legal ambiguities, and administrative barriers that hinder the formal integration of E-3Ws into the urban transport system. It also investigated electric mobility policies, alongside practical implementation experiences from cities such as Ludhiana in India and policy approaches applied in Kandy, Sri Lanka. In cases where formal policy documents were limited, the analysis was supported by peer-reviewed studies, grey literature, and reports from international development organizations. All documentary sources were reviewed thematically, focusing on four key areas: the formal recognition of electric three-wheelers (E-3Ws) within regulatory frameworks, requirements for vehicle registration and driver licensing, enforcement practices, and the extent to which these vehicles are integrated into broader urban transport planning systems.

3 Regional landscape of electric three-wheelers

The rapid proliferation of electric three-wheelers (E-3Ws) across South Asian secondary cities reflects a structural transformation in urban mobility provision. However, from the empirical evidence in Bangladesh, and by comparing some of the key indicators in India and Sri Lanka, it can be argued that E-3Ws have become embedded in the urban travel system. This section synthesizes travel behavior patterns, operational characteristics, and cost efficiency across the selected case study cities to contextualize their regional role.

3.1 Travel pattern and trip distance structure

The proportions of trip length for the travel behavior shown in Table 1 indicate that urban trips in the secondary cities are largely shorter in length (< 5km). More than 80% of the total trips fall within this range, accounting for 87% of Narayanganj, 89.6% of Gazipur, and 82.4% of Ludhiana. Within this short-distance urban mobility pattern, electric three-wheelers (E-3Ws), represented as battery vehicles in the dataset, play a significant role across the study cities. Evidence from both Narayanganj and Gazipur indicates that E-3Ws account for a large share of trips, particularly in the 1–5 km distance band, where walking becomes less practical but conventional public transport remains relatively inaccessible. For instance, it carries four, six, and three times as many trips as formal bus service in Narayanganj (29.5%), Gazipur (53.4%), and Ludhiana (14.7%), respectively. Specifically, it accounts for 24.42% of trips of 1–2 km in Gazipur, the highest amongst all mechanized modes in that distance category. An almost similar trend has been observed for E-3Ws in Narayanganj, where they made 12.99% of trips with a trip length within the 1–2 km range and also commanded significant shares in the 2–5 km distance band. Secondary data from Ludhiana suggest a similar pattern, as E-3Ws also account for short- and medium-distance trips in that region (~ 2–5 km). This similarity in spatial distribution across contexts with comparable mobilities indicates that E-3Ws play a similar role in the mobility systems of South Asian secondary cities.

In short-distance travel, door-to-door service, high availability, and operational flexibility contribute to their success for essential daily trips like commuting to nearby workplaces or hospitals, or moving items for local market activities, which are often impossible to do by walking and require even more effort over relatively short distances. Their compact size, affordability, and ability to operate on narrow local streets further enhance their suitability for dense urban spaces. In addition, E-3Ws serve as feeder routes to public transport, connecting residential areas with major corridors and transit stops. By enabling these first- and last-mile journeys, they enhance accessibility and increase the effective range of formal public transport systems. Thus, E-3Ws seem to play an essential role in meeting proximity-mobility needs and can help fill the mobility gap between non-motorized travel and high-capacity public transport in fast-growing secondary cities.

Table 1
Trip length distribution by mode across study cities

City	Trip Length (km)	Walking	Bicycle	E-3Ws	Laguna/Human Hauler/ CNG Auto Rickshaw	Private Vehicle	Public Transport
Narayanganj	<=1	51.06%	0.04%	3.03%	0.19%	0.02%	0.00%
	1–2	0.92%	0.10%	12.99%	0.62%	0.09%	0.10%
	2–3	0.00%	0.16%	7.79%	0.78%	0.03%	0.74%
	3–5	0.03%	0.07%	4.80%	0.87%	0.62%	1.97%
	More than 5	0.00%	0.00%	0.84%	1.14%	7.04%	3.94%
Gazipur	<=1	24.29%	0.01%	8.05%	0.01%	0.03%	0.04%
	1–2	3.69%	0.33%	24.42%	0.06%	0.33%	0.85%
	2–3	0.09%	0.33%	10.58%	0.07%	1.20%	1.18%
	3–5	0.01%	0.69%	8.25%	0.20%	2.41%	2.46%
	More than 5	0.01%	0.00%	2.17%	0.34%	3.52%	4.36%
Ludhiana	<=1	24.41%	3.81%	0.92%	-	4.93%	0.27%
	1–2	6.27%	3.80%	2.67%	-	6.88%	0.64%
	2–3	0.86%	2.31%	3.75%	-	4.42%	0.66%
	3–5	0.00%	2.89%	4.04%	-	7.35%	1.48%
	More than 5	0.00%	2.14%	3.29%	-	10.05%	2.16%

The short trips under five kilometers by income level exhibit a correlation between socio-economic status and travel choices in both cities, Narayanganj and Gazipur. The relation is almost linear in terms of economic condition, while the gender gradient shows considerable skewed relationship. In Narayanganj, the ratio of E-3Ws and bus users is almost similar, with E-3Ws being 1% higher than buses. In Gazipur, the ratio of low-income users using E-3Ws is 5% higher than buses. In contrast, women in both cities prefer to use E-3Ws 5–7 times more than buses in their day-to-day trips. The huge disparity indicates that E-3Ws bring more safety and convenience for the women passengers.

3.2 Accessibility and network coverage

The distribution of road hierarchy across the study cities further clarifies the indispensable role of E-3Ws in providing urban access. As shown in Fig. 3, local roads constitute most road networks in each city: 403 km of 593 km total in Narayanganj, 2,621.2 km of 2,833.8 km in Gazipur, 1,844.4 km of 2,181.1 km in

Ludhiana, and 25.02 km of 58 km in Kandy. These figures indicate that a large portion of urban travel originates from neighborhoods served primarily by local and collector streets rather than arterial corridors.

The Institute for Transportation and Development Policy (ITDP) suggests that regular bus services work best on main and secondary roads, where there is enough space and traffic flow for them to run efficiently. Using this standard, buses can directly cover only 8.6% of Narayanganj's roads (51 km out of 593 km), 3.0% in Gazipur (85.5 km out of 2,833.8 km), 15.4% in Ludhiana (336.7 km out of 2,181.1 km), and 56.7% in Kandy (32.74 km out of 57.76 km). This means that if cities rely only on buses, many residential areas will not have easy access to public transport. On the other hand, electric three-wheelers (E-3Ws) can operate on a wider range of roads, from main distributor roads to small local streets. Their compact size and ability to move through narrow and crowded areas make them well-suited for places where larger vehicles cannot go. Because of this, E-3Ws are important for connecting neighborhoods to main activity centers and bus routes. They do more than just support regular public transport; they help reach areas that buses cannot serve.

3.3 Operational characteristics

3.3.1 Vehicle occupancy and travel speed

Operational performance indicators further illustrate the functional role of electric three-wheelers (E-3Ws) within the urban transport systems of the study cities. Table 2 summarizes key operational characteristics, including vehicle occupancy and average travel speed, across transport modes in Narayanganj, Gazipur, Ludhiana, and Kandy.

Table 2
Vehicle occupancy and travel speed by mode and city

City	Mode	Vehicle occupancy	Travel Speed (km/hour)
Narayanganj	E-Rickshaw	1.61	7.98
	Easy Bike	4.09	11.21
	Bus	31.94	13.88
Gazipur	E-Rickshaw	2	13.3
	Easy Bike	2.7	14.7
	Bus	37.2/22.4	16
Ludhiana	E-Rickshaw	-	-
	Easy Bike	3.96	-
	Bus	22.46	-
Kandy	E-Rickshaw	-	-
	Easy Bike	1- 1.7	-
	Bus	40.4–56.7	-

In Narayanganj, E-rickshaws operate with an average occupancy of 1.61 passengers per vehicle and an average travel speed of 7.98 km/h under mixed-traffic conditions. Although this speed is lower than other mechanized modes such as easy bikes (11.21 km/h) and buses (13.88 km/h), it reflects the operational context of dense urban streets with frequent stopping and passenger boarding. Despite the lower speed, the moderate occupancy level enables E-3Ws to serve short-distance passenger demand efficiently, particularly within local and collector roads. A slightly higher performance is observed in Gazipur, where E-rickshaws carry approximately 2 passengers per vehicle and operate at an average speed of 13.3 km/h. In comparison, easy bikes carry around 2.7 passengers and travel at 14.7 km/h, while buses operate at 16 km/h with significantly higher passenger loads (approximately 22–37 passengers per vehicle). Secondary data from Ludhiana and Kandy also highlight similar occupancy structures for intermediate public transport modes. In Ludhiana, easy bikes carry approximately 3.96 passengers, while buses accommodate around 22.46 passengers per vehicle. In Kandy, easy bike occupancy ranges between 1 and 1.7 passengers, whereas bus occupancy varies between 40.4 and 56.7 passengers per vehicle, reflecting their role as high-capacity corridor-based transport. Overall, these operational indicators demonstrate that E-3Ws occupy a distinct functional niche within the urban mobility system. While they do not match the passenger capacity of buses, their moderate occupancy levels, combined with relatively stable travel speeds, allow them to efficiently serve short-distance and feeder trips within dense urban networks that formal services are neither designed nor able to efficiently accommodate.

3.3.2 Vehicle operating cost (VOC) and economic efficiency

Electric three-wheelers (E-3Ws) are revealed as affordable transportation options by their total operational cost, which is much cheaper than conventional public transportation modes. As shown in Table 3, calculated for Narayanganj city, the vehicle operational cost of an easy bike, at 9.6 BDT per km, is about 4.3 times less than a large bus (41.3 BDT per km) and 3.7 times less than a microbus (35.4 BDT per km). In addition, e-rickshaws have the lowest vehicle operational costs among the assessed modes, even 10% less than easy bikes. The considerable cost benefit highlights the economic viability of E-3Ws for short- to medium-distance urban travel, where e-rickshaws are the ultra-low-cost alternative for local mobility needs. The cost-benefits of these low-cost modes make them highly suitable for facilitating accessible and affordable transportation, especially in cities where budget constraints may prohibit the construction or operation of high-capacity systems.

Table 3
Vehicle cost comparison among existing transport modes (Narayanganj)

Mode	Capital Cost (BDT)	Maintenance Cost (BDT/year)	VOC (BDT/year)	Total Cost per km (BDT)
Easy Bike	7,062	12,000	141,792	9.6
E-Rickshaw	1,953	12,774	125,789	1.0
Car	88,603	96,755	462,347	24.7
Large Bus	271,502	168,003	1,227,636	41.3
Minibus	153,290	180,006	923,278	29.4
Microbus	158,095	136,006	533,744	35.4

3.3.3. Environmental impact of existing transport modes

To capture the environmental impact scenario of transportation modes, a comparison of the fuel consumption in the NCC is shown in Table 4. It emphasizes that electric motors and batteries are the main sources of power for three-wheelers, including battery-operated rickshaws and easy bikes. E-rickshaws and easy bikes are powered entirely by electricity, producing no tailpipe emissions during the use phase. On the other hand, buses that run on petrol, diesel, or gasoline have a substantial impact on greenhouse gas emissions.

Table 4
Environmental Impact of Existing Transport Modes (Narayanganj)

Mode	Vehicle km	Fuel Type	Fuel Consumption (per person)	Total Emission (ton/year)	Pollution rating (per veh-km)
Pedestrian	None	None	None	None	None
E-Rickshaw	630,699	Electric	None	None	None
Easy Bike	4,320,056	Electric	None	None	None
Bus	20,340,249	Petrol/Diesel/Gasoline	Moderate	9300	Moderate
Car	45,626,683	Octane/Gasoline	High	8089	High

In Narayanganj, for example, buses travel 20,340,249 vehicle kilometers and release about 9,300 tons of CO₂. Similarly, private vehicles, such as cars that operate on octane and gasoline, release approximately 8,089 tons of CO₂ while travelling 45,626,683 kilometers. This data highlights the high amounts of pollution associated with traditional fuel-powered vehicles. When comparing these modes, e-rickshaws and easy bikes emit significantly less CO₂ per vehicle-kilometer. Their only environmental impact is the indirect cost of electricity used for charging. This is in stark contrast to public buses and private vehicles, which emit large volumes of greenhouse gases into the atmosphere. Thus, incorporating e-rickshaws and easy bikes into urban transportation planning can help to create a more sustainable and environmentally friendly transportation system.

4 Regulatory and governance challenges of electric three-wheelers

The prior analysis demonstrates that electric three-wheelers generate real benefits across multiple dimensions of urban transport performance: they extend spatial accessibility deep into local street networks that formal buses cannot cover, offer affordable door-to-door mobility for the short-distance trips that governs daily travel demand in South Asian secondary cities, operate at competitive speeds with significantly lower vehicle costs than formal public transport, and produce no tailpipe emissions during use; representing a considerable improvement over the fossil-fuel-powered vehicles they replace. However, this evidence stands in productive tension with well-documented concerns. The unregulated growth of E-3W fleets has created ongoing challenges in traffic congestion, road safety, and battery lifecycle management, leading to fragmented policy responses ranging from informal tolerance to outright bans. This tension fuels the central debate animating academic literature and policy discourse in South Asia: whether the unmanaged proliferation of E-3Ws has rendered them a source of urban dysfunction, contributing to congestion and environmental risk, or whether they represent underutilized tools of accessible, affordable, and low-carbon urban mobility whose potential remains unrealized in the absence of coherent governance. In response to the debate, policymakers don't support its functionality; instead, they try to control it through inconsistent regulations, bans, and institutional ambiguity. This

section addresses that gap by examining the regulatory landscape across the four case study cities, revealing that the governance challenges surrounding E-3Ws are not simply administrative failures but reflect deeper structural tensions between the speed of informal market-driven adoption and the institutional capacity of urban transport authorities to respond coherently, tensions whose resolution is essential for translating the empirical findings of Sections 3 into actionable policy and for developing the tiered framework presented in Section 5.

4.1 Policy landscape across case study cities

4.1.1 Bangladesh: Informal Expansion and Regulatory Ambiguity

In Bangladesh, E-3Ws have grown rapidly without clear formal regulation. Their growth has largely been driven by market demand rather than coordinated transport planning. Local authorities have often responded with temporary restrictions or partial bans, instead of implementing a structured system such as licensing or route planning. As a result, the sector operates in an unregulated framework in which route allocation, fleet size, and operational standards remain largely uncontrolled, which leads to ongoing debates regarding congestion, traffic discipline, and road safety, even though these vehicles play a significant role in addressing local mobility needs.

4.1.2 India: Partial Formalization and Regulatory Integration

India has made more systematic efforts to incorporate electric three-wheelers into formal regulations. Policies such as the national electric mobility framework and state-level registration programs have enabled legal recognition of electric rickshaws, such as vehicle registration, driver's license, and specific zones of operation in several cities, including Ludhiana. However, implementation is inconsistent, and cities differ significantly in how effectively they can enforce them. Although the regulatory framework is more defined than that in Bangladesh, there are still challenges related to route management, fleet control, and traffic discipline.

4.1.3 Sri Lanka: Incentive-Oriented Transition Policies

In Kandy, the policy approach has been more organized as the government provides incentives to encourage the adoption of electric mobility. Regulatory attention has focused on reducing dependence on fossil-fuel-based three-wheelers while supporting cleaner transport alternatives. However, their integration into the broader transport network still faces operational and planning challenges, especially in balancing their role with formal bus services and pedestrian infrastructure, which has prevented them from achieving system-wide benefits.

4.2 Common cross-border governance challenges

Despite differences in national policy approaches, several governance challenges appear consistently across the region, each corresponding directly to one of the concerns at the centre of the E-3W policy controversy.

4.2.1 Traffic Safety and Operational Discipline

The rapid growth of E-3W fleets, along with limited driver training and limited enforcement of traffic rules, has led to safety concerns in heterogeneous traffic environments. Informal stopping practices, sudden passenger pick-ups, and competition for road space with other vehicles often create localized conflicts within congested corridors. It is important, however, to locate these safety concerns within their governance context because safety risks associated with E-3Ws in mixed traffic are consequences of the absence of spatial organization in their operations, a governance failure rather than a vehicle failure. In this case, introduction of dedicated service lanes can produce significant improvements in network performance.

4.2.2 Battery Lifecycle and Environmental Management

The management of battery lifecycles presents an emerging environmental concern, even though E-3ws do not produce tailpipe emissions during operation. The proper management systems for battery recycling, safe disposal, and end-of-life management are still not well developed in many South Asian cities.

4.2.3 Modal Competition and Integration with Formal Transport

The rapid expansion of E-3Ws has also generated institutional tensions with operators of formal public transport, particularly buses. Transport operators in several cities argue that the unregulated growth of the fleet increases congestion and erodes passenger demand for scheduled services, driving periodic policy responses that treat E-3Ws primarily as competitive threats. The empirical evidence presented in this study challenges this framing: the trip pattern analysis in Section 3 demonstrated that E-3W demand is concentrated in the short-distance range that buses are least well-suited to serve. These findings indicate that E-3Ws function primarily as feeder and distributor services complementary to, rather than in competition with, formal public transport corridors.

The regulatory landscape described in this section reveals a governance paradox. The E-3W sector across South Asia is not merely ungoverned; it is actively misgoverned in the sense that prevailing policy responses have been calibrated primarily around the concerns associated with informal E-3W operations rather than around the empirically demonstrable benefits of organized integration. Each year without coherent policy frameworks represents a continued loss of the travel time savings, emission reductions, and accessibility improvements that Section 4 demonstrates are achievable. The regulatory vacuum does not simply fail to capture the potential benefits of E-3Ws; it actively prevents their realization, because the operational organization required to generate those benefits is itself a product of regulatory

action. This reframes the central question posed in Section 3. The debate over whether E-3Ws are 'part of the problem or part of the solution' is ultimately a debate about governance, not about vehicles. As informal, unregulated operators, E-3Ws generate legitimate concerns about safety, congestion, and environmental management. As formally integrated components of a planned urban transport system, organized spatially, regulated operationally, and supported institutionally, they can generate measurable improvements across each of these same dimensions. The policy implication is unambiguous: the transformation of E-3Ws from urban problems to urban solutions is not a technical challenge but an institutional one, and it is that institutional challenge that Section 5 addresses.

5 Discussion: Towards a tiered policy framework for strategic e-3w integration

The findings of sections 3 and 4 collectively build a strong foundation for a fundamental reorientation of E-3W policy across South Asia. Section 3 presents that E-3Ws play a major role in expanding mobility into local street networks, especially by providing short-distance trips at affordable fares, along with offering zero tailpipe emission travel transport where other transport modes are limited. Section 4 identified the governance paradox at the heart of the sector: the problems most frequently attributed to E-3Ws are not consequences of their operational nature but of the regulatory vacuum in which they operate. Together, these outcomes resolve the central debate introduced in Section 3: E-3Ws are not a problematic mode of transport; they become so only in the absence of governance. The policy challenge is therefore not whether to incorporate E-3Ws, but how to control them in ways that maximize their benefits while addressing the concerns around safety, congestion, driver welfare, and battery lifecycle. This section proposes a tiered, context-sensitive policy framework to incorporate E-3w across the diverse institutional and urban environments of South Asia.

5.1 A tiered policy framework for strategic e-3w integration

5.1.1 Tier 1: Foundational Regulation: Establishing Legal and Institutional Recognition

The first and most urgent tier addresses the legal and institutional invisibility of E-3Ws in cities such as Narayanganj and Gazipur, where vehicles operate in a complete regulatory vacuum. At this level of intervention, the key priorities are creating a reliable legal definition of E-3Ws in national transport law; mandatory vehicle registration with safety standards; and basic driver licensing with minimum training requirements and competency to drive. These measures do not suppress E-3W operations; instead, they are preconditions for all subsequent policy tiers. In the absence of legal recognition, operators have no access to formal financing; drivers cannot receive employment protection, and authorities cannot do route management or enforce safety. The Draft Electric Motor Vehicle Registration and Operation Guideline (2023) in Bangladesh provides a starting point, but it should be shaped into enforceable directives with clear institutional responsibilities and timelines.

5.1.2 Tier 2: Network Integration: Formalizing Operations Within the Urban Mobility System

Once legal recognition is established, the second tier concentrates on integrating E-3W operations into the planned urban transport network. Tier 2 interventions include: designated pick up and drop points for the passengers to banish informal stopping habits which causes local traffic conflicts, dedicated lane prioritization on major feeder routes that connects residential areas to public transport nodes, spatial route planning to formalize E-3Ws as a structured feeder layer within the urban mobility system, and transparent fare schemes linked to operational cost benchmarks to protect both passengers and drivers from economic exploitation. Together, these measures transform disorganized movement into a coordinated feeder network that improves the performance of higher-capacity public transport corridors.

5.1.3 Tier 3: Network Integration: Integrating E-3Ws into Sustainable Urban Mobility Systems

The third tier is applicable to cities that have achieved foundational regulation and network integration, such as Ludhiana and Kandy, and can thus utilize E-3W deployment as a tool of sustainable urban development. At this level, the attention shifts from managing existing informal operations to actively integrating E-3W systems into a low-carbon urban transport ecosystem. Critical Tier 3 interventions involve green financing schemes to develop solar-powered charging infrastructure, further mitigating lifecycle emissions related to electricity production and strengthening the sustainability credentials of the E-3W sector. The reductions in tailpipe emissions provide a quantitative basis to secure green bonds, climate funds, and carbon credit schemes. If used in renewable energy and environmental finance, E-3Ws may help cities create a positive cycle: better environmental performance attracts funding, funding improves infrastructure, and improved infrastructure further boosts environmental performance.

The comparative study across Bangladesh, India, and Sri Lanka offers transferable lessons: Bangladesh shows the cumulative cost of regulatory inaction; India's experience in Ludhiana highlights the limits of partial formalization when implementation is uneven; and Kandy's incentive-oriented approach in Sri Lanka illustrates how enabling policies without network-level planning do not deliver system-wide benefits. The tiered framework integrates these lessons into a governance architecture that can be adapted to the specific institutional contexts, urban forms, and E-3W market conditions of each city. As secondary cities across South Asia continue to expand and travel demand grows, the decisions made over the next decade will determine whether E-3Ws become a reliable, well-organized mode of transport or remain stuck in informal operation and ongoing regulatory challenges.

6 Conclusion

This study aimed to address a fundamental and consequential debate in South Asian urban transport policy: whether electric three-wheelers are part of the urban mobility problem or part of its solution. The

regional analysis of Narayanganj, Gazipur, Ludhiana, and Kandy demonstrated that E-3Ws are not merely temporary or minor parts of the urban transport landscape. They are deeply integrated transport providers, serving the short-distance trips that dominate daily travel demand in secondary cities, extending mobility into local street networks that are inaccessible to formal public transport modes, and doing so at the cost of conventional public transport. Due to their spatial and economic characteristics, they fit perfectly in the gap of first- and last-mile connectivity, which is where formal transit systems consistently fail to address.

The regulatory review in Section 4 identified the governance paradox that explains why these benefits remain largely unrealized, as the relevant authorities often view E-3Ws as a problem rather than a resource. Because of that, they either don't regulate them properly or put unclear rules in place for operation. The consequence is a self-reinforcing cycle in which the absence of regulation produces disorganized operations that justify further restrictions, preventing the sector from demonstrating its capacity to operate in an organized and efficient way. Each year without clear and consistent regulatory systems represents a quantifiable, unnecessary loss of mobility and environmental benefits.

In response, this study suggests a tiered, context-sensitive policy framework that delivers a systematic pathway from informal tolerance toward full strategic integration, calibrated to the institutional capacity and regulatory maturity of individual cities. The framework's three tiers- foundational regulation, network integration, and strategic development- address the full spectrum of governance challenges identified in Section 5, from legal recognition and driver licensing to green financing and renewable energy incorporation. Importantly, the framework is based on the empirical results of this study, not on prescriptive planning ideals: each recommended intervention has evidence supporting the benefits it aims to capture.

The study's findings have implications beyond the four cities studied. Hundreds of secondary cities across South Asia face the same mobility gap, the same proliferation of informal E-3Ws, and the same governance paralysis observed in Narayanganj and Gazipur. The proposed framework aims to provide a transferable governance architecture that cities can design for their specific institutional, urban, and market contexts. Regional policy learning, drawing on the comparative experiences of Bangladesh, India, and Sri Lanka, is identified as an essential mechanism for accelerating this adaptation.

The broader contribution of this study is to reframe the intellectual and policy discourse surrounding electric three-wheelers. Rather than treating E-3Ws as an informal anomaly to be managed or eventually replaced, this research enables them as strategic mobility assets, vehicles that, when properly governed, can simultaneously advance accessibility, affordability, and environmental sustainability in rapidly urbanizing secondary cities. The transformation required is not primarily technical. The vehicles exist, the demand exists, and the benefits have been demonstrated. What is required is the institutional will to govern these vehicles as the strategic urban transport assets they are, as the evidence shows.

Future research should expand the simulation-based impact assessment, including lifecycle emissions analysis to capture the grid carbon intensity aspect of E-3W environmental performance, and assess

long-term fiscal and social outcomes from implemented policy tiers. Studying cities over time that have introduced governance reforms would help to provide useful evidence to improve the tiered framework and amplify its empirical basis. The direction is clear for both research and policy: moving from informal, improvised solutions to planned and strategic integration.

Declarations

Use of AI

During the preparation of this work, the author(s) used Claude in order to improve and correct the grammar and spelling of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Funding

The survey was conducted under the Comprehensive Transport Masterplan for Narayanganj and Gazipur City Corporation project. The research itself received no funding — it was done entirely on the authors' own initiative.

Clinical trial number

Not applicable.

Ethics, Consent to Participate, and Consent to Publish declarations

Not applicable as the research involved household travel survey with no medical and sensitive data collected and all the respondents participated with their consent.

Author Contribution

A.A.F. and S.K. designed the study. F.F., M.F.M.Z., L.M. and S.R. carried out the data analysis. F.F. and S.K. wrote the main manuscript text. F.F and S.K reviewed and edited the manuscript.

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Figures

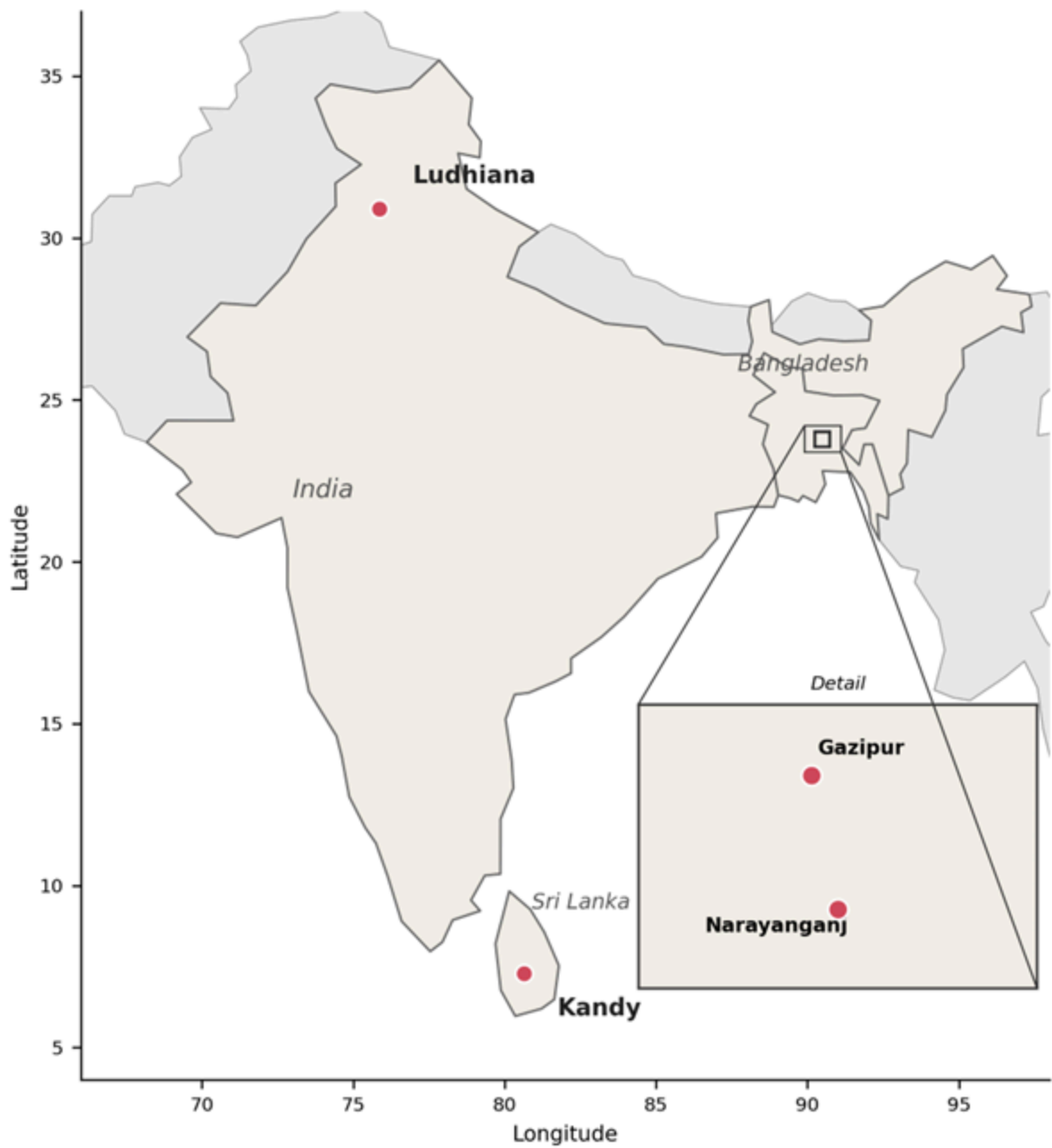


Figure 1

Map of Study Area

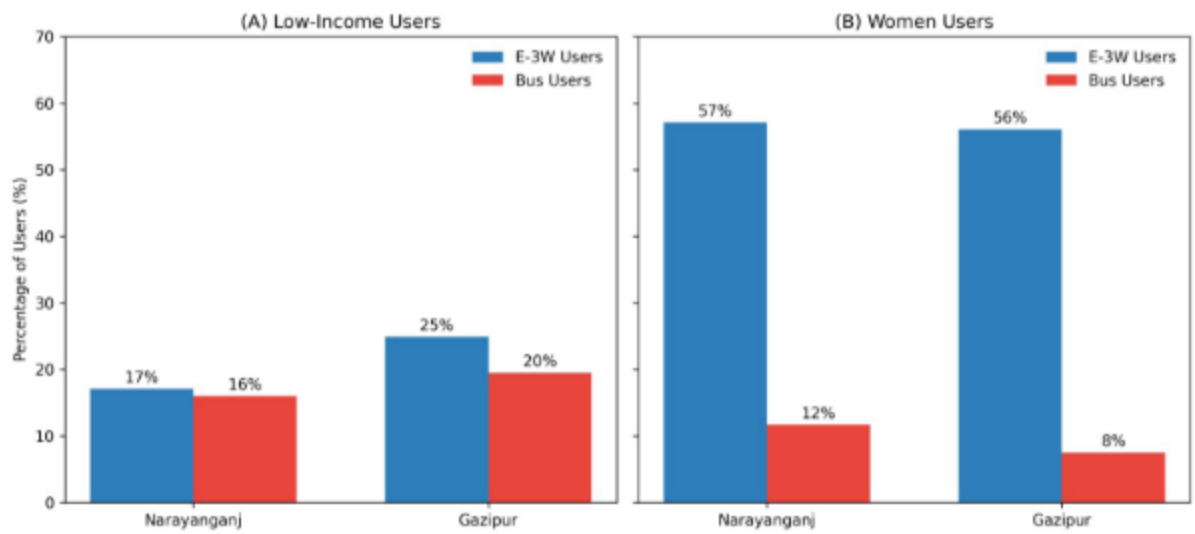
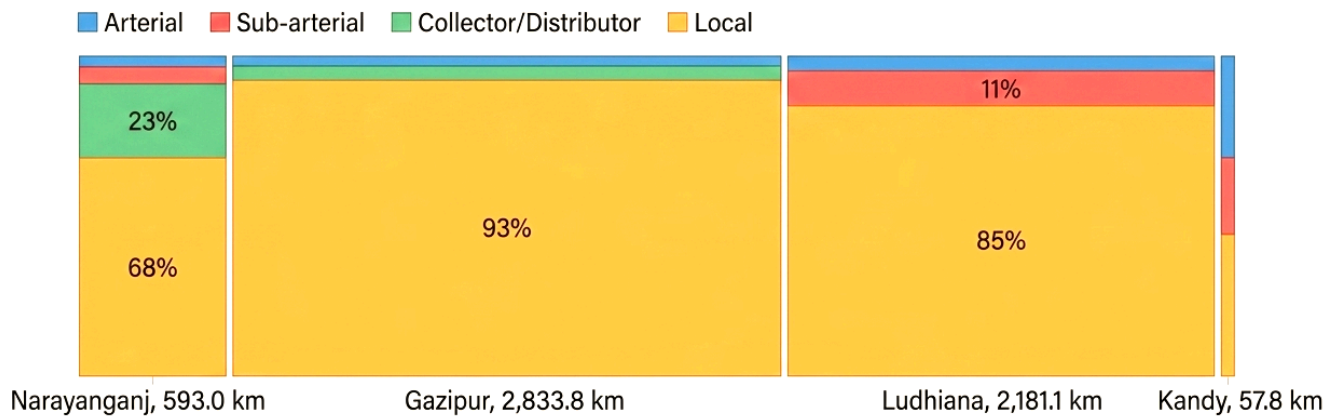


Figure 2

Socio-Economic Gradient in Mode Use



DETAILED ROAD LENGTH DATA (km)

	Narayanganj (km)	Gazipur (km)	Ludhiana (km)	Kandy (km)
Arterial	19.0	85.5	102.3	18.29
Sub-Arterial	32.0	—	234.4	14.45
Collector/Distributor	139.0	127.1	—	—
Local	403.0	2,621.2	1,844.4	25.02
Total (km)	593.0	2,833.8	2,181.1	57.76

Figure 3

Road network hierarchy across study cities