**Chapter 1**

**Introduction**

`Introduction

1.1 Background of the Study

Dhaka, the capital of Bangladesh, stands as one of the most densely populated metropolitan areas worldwide, with a population exceeding 21 million as of 2022 (World Bank, 2022). This rapid urbanization has exerted immense pressure on the city’s transportation system, which comprises a complex mixture of formal and informal public transport modes. Formal options such as buses and the newly introduced Mass Rapid Transit (MRT) co-exist with informal services including leguna (minivans), auto-rickshaws, cycle rickshaws, and human haulers—modes that collectively sustain the mobility needs of millions daily (Mahmud & Rabbani, 2012; BRTA, 2021).While these diverse modes provide critical connectivity, the transport ecosystem is characterized by pervasive challenges. Traffic congestion is acute, resulting in average travel speeds often below 7 km/h during peak periods, significantly hampering productivity and quality of life (BRTA, 2021). The prevalence of diesel-based and poorly maintained vehicles contributes substantially to severe air pollution, making Dhaka one of the most polluted cities globally. This environmental degradation threatens public health and exacerbates social inequalities, as lower-income residents typically endure longer commutes, higher exposure to pollution, and greater safety risks (Khan & Islam, 2019; Chowdhury & Imran, 2020).Furthermore, the transport system’s reliance on informal modes reflects systemic gaps in infrastructure and regulation, but also reveals the critical importance of affordability and accessibility for the city’s poor majority (Mahmud & Rabbani, 2012). Public transport fares are set without systematic consideration of equity or the financial realities of vulnerable populations, often resulting in disproportionate cost burdens for low-income users (RSTP, 2016). Consequently, the existing transport paradigm in Dhaka embodies a complex interplay between service diversity, environmental degradation, and social inequity, underscoring the urgent need for integrated, welfare-enhancing policy frameworks.

1.2 Statement of the Problem

Despite widespread recognition of Dhaka’s transport challenges, there remains a conspicuous absence of a comprehensive analytical framework to evaluate and compare transport modes through the lens of social welfare. Current decision-making processes predominantly emphasize operational efficiency, financial sustainability, or incremental infrastructure upgrades, often overlooking broader societal impacts such as equity, environmental externalities, and user benefits (Sardjono, 2020; The Daily Star, 2025).Fare policies and subsidies are typically formulated without explicit consideration of income disparities or affordability constraints, limiting equitable access to essential public transport services (Mahmud & Rabbani, 2012). Moreover, environmental externalities—such as congestion-induced delays and transport-related emissions—are seldom quantitatively integrated into mode evaluation or policy prioritization (Khan & Islam, 2019). This lack of a holistic, welfare-oriented evaluation framework means that transport modes are rarely assessed in terms of their net contribution to societal well-being, leaving the door open for policy decisions that may inadvertently perpetuate inequality, environmental harm, and inefficiency.

1.3 Purpose and Significance of the Study

The purpose of this study is to explore how people in Dhaka choose among different public transport options, focusing particularly on how factors such as cost, travel time, comfort, and income levels influence these decisions. With the rapid growth of the city and increasing pressure on its transport systems, understanding these choices has become essential for planning a more efficient and inclusive transport network. This research seeks to examine whether current public transport services meet the needs of all groups in society, especially lower-income and vulnerable populations who often face greater challenges in accessing affordable and reliable transportation. By assessing the trade-offs that commuters make such as choosing between time savings and higher fares this study highlights the real-world experiences of daily travelers. The significance of the study lies in its potential to inform future policy decisions related to urban transport planning, fare systems, and public investment. The findings may guide efforts to make transport services not only more efficient but also more equitable. In a city where traffic congestion, long commuting times, and economic disparities are common, developing a deeper understanding of public transport preferences can lead to more effective solutions that improve daily life for a wide range of people. Moreover, the study contributes to the broader discussion on how cities in developing countries like Bangladesh can create transport systems that support both economic development and social equity. By placing the voices and choices of commuters at the center of the analysis, this research provides valuable insight into how public transport can better serve the people who rely on it most.

1.4 Research Objectives

The primary goal of this study is to develop a model that evaluates public transport modes in Dhaka with a focus on improving social welfare. The study recognizes that public transport plays a vital role in the daily lives of city residents, and seeks to explore how different modes meet the needs of various user groups.

The specific objectives of the study are:

1. To assess user preferences and affordability constraints across different income groups for various public transport modes in Dhaka city.
2. To model and compare the social welfare outcomes of each transport mode, including user benefits, operator costs, and environmental externalities.
3. To examine the role of travel time and other key factors influencing mode choice in shaping public transport use in Dhaka city.

1.4.1 Research Questions

To guide this study, the following research questions will be addressed:

1. How do fare, travel time, and service quality affect public transport mode choice among different income groups in Dhaka?
2. What are the social welfare impacts considering user benefits, operator costs, and environmental effects of different public transport modes in Dhaka?
3. How do travel time, waiting time, and other mode choice factors influence passenger decisions and equity outcomes in Dhaka’s public transport system?
4. What fare and subsidy policies can best improve accessibility and affordability for low-income users without compromising financial sustainability?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Objective | Sub-Objective | Data Source | General Method / Model | Specific Technique / Tool |
| 1. To assess user preferences and affordability constraints across different income groups for various public transport modes in Dhaka city. | 1.1 Assess how fare, travel time, and service quality affect mode choice among different income brackets | Stated Preference (SP) survey (primary data) | Discrete Choice Modeling | Multinomial Logit Model (RUM Framework) using Python (e.g., statsmodels, pylogit) |
|  | 1.2 Analyze affordability thresholds and willingness to pay for improved services | Income Fare matrix, SP responses | Valuation Analysis | Contingent Valuation Method (CVM), Fare Elasticity Estimation |
| 2.To model and compare the social welfare outcomes of each transport mode, including user benefits, operator costs, and environmental externalities | 2.1 Quantify welfare outcomes under different mode-specific scenarios | SP + secondary data (e.g., DTCA, operator costs, emissions data) | Welfare Optimization Model | Max-R, Max-P, Max-B, Max-D, Max-S models using GAMS |
|  | 2.2 Compare cumulative social welfare impacts across modes | Combined dataset | Comparative Policy Evaluation | Multi-criteria Decision Matrix (MCDA), Weighted Scoring |
| 3. To examine the role of travel time and other key factors influencing mode choice in shaping public transport use in Dhaka city. | 3.1 Identify the role of travel time, waiting time, and transfer inconvenience in mode selection | SP data, GIS travel time layers | Accessibility & Utility Modeling | Generalized Cost Function, Equity Gap Analysis |
|  | 3.2 Evaluate equity-sensitive fare/subsidy policies and their distributional impact | SP data + Policy limits (e.g., from DTCA) | Scenario Simulation | Policy Optimization under Constraints (e.g., Subsidy ≤ 10%) |

1.6 Justification of the Study

Dhaka, the capital of Bangladesh, is one of the fastest-growing megacities in the world, with a population that has now surpassed 21 million (World Bank, 2022). This rapid growth has placed enormous pressure on the city’s transport system, which struggles to provide efficient and accessible mobility for its residents (UN-Habitat, 2020). Despite various efforts and programs aimed at improving urban transport, Dhaka continues to face serious challenges such as heavy traffic congestion, rising air pollution, and social inequalities in access to transportation (Asian Development Bank, 2019). These issues not only cause daily inconvenience for millions of commuters but also affect the city’s overall economic productivity and the health of its population (WHO, 2021).

Dhaka’s transport landscape is highly complex, with a mix of formal options like buses and the recently launched metro rail, alongside informal modes including leguna, auto-rickshaws, and cycle rickshaws. These informal services remain essential for low-income communities and people living in areas with limited access to formal transport (Haque & Sultana, 2018). This dual system reflects the economic challenges, limited infrastructure, and social diversity that shape the city’s mobility patterns (Sutcliffe et al., 2017). A major weakness in current transport planning for Dhaka is the lack of a comprehensive framework that can assess and compare different transport modes through the lens of social welfare (Islam & Rahman, 2021). Presently, decisions tend to focus on operational efficiency and financial factors, such as recovering costs through fares or gradually expanding infrastructure (World Bank, 2019). However, this narrow focus often overlooks important issues like how affordable the services are, whether they meet users’ needs, and what impacts they have on equity and the environment (ADB, 2019). As a result, fare and subsidy policies sometimes deepen existing inequalities, making it harder for vulnerable groups to access reliable transport, while also failing to address pollution and congestion problems caused by traffic emissions (Haque & Sultana, 2018).Given these challenges, there is an urgent need to adopt a more inclusive and integrated approach to transport planning in Dhaka. This study aims to develop such a framework that takes into account multiple factors—user preferences, affordability, operator costs, and environmental impacts—to provide a clearer and fairer understanding of how well the city’s transport modes serve different social groups. Such an approach is essential for guiding policies that not only ensure economic sustainability but also promote social fairness and protect the environment, paving the way for a more balanced and livable Dhaka.

1.7 Scope and Limitations of the Study

This study is focused on evaluating the social welfare implications of different public transport modes operating within Dhaka city, emphasizing user preferences, affordability constraints, and the integration of environmental externalities. The research encompasses both formal and informal modes of transport that constitute the primary means of urban mobility for Dhaka’s residents, including buses, metro rail, leguna, and cycle rickshaws. Data collection will primarily rely on a structured stated preference survey targeting a representative sample across diverse income groups and geographic locations within the city. The analysis will consider key factors such as fare levels, travel time, comfort, and environmental impacts; however, the study does not extend to the operational management or infrastructural specifics of the transport services. Environmental externalities such as emissions and congestion are incorporated based on secondary data sources and established valuation metrics, which may constrain the granularity and real-time applicability of the environmental assessment. Several limitations are inherent in this research. The reliance on stated preference surveys may introduce biases stemming from hypothetical scenarios that differ from actual traveler behavior. Additionally, Dhaka’s dynamic transport landscape, characterized by rapid growth and frequent policy changes, may affect the temporal relevance of the findings. Despite these challenges, the study is designed to deliver robust insights that can meaningfully inform policy formulation and contribute to the development of a more equitable and sustainable urban transport framework for Dhaka.

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**Chapter 2**

**A Comprehensive Review of Social Welfare, Equity, and Fare Optimization in Public Transport**

2.1 Introduction

Urban transport systems play a central role in shaping economic opportunity, social inclusion, and environmental sustainability. In rapidly growing cities, particularly across the Global South, the design of public transport systems must navigate a complex set of objectives—balancing operational efficiency, financial viability, equity, and environmental responsibility. Against this backdrop, modeling social welfare in urban public transport offers a powerful framework to evaluate how fare structures, service levels, and policy interventions affect the well-being of both users and providers, while accounting for broader societal impacts such as congestion, emissions, and affordability. This chapter explores the theoretical foundations and practical applications of welfare-based transport modeling. It brings together key strands of literature from transport economics, operations research, and policy studies to present a structured review of how social welfare has been conceptualized, quantified, and applied in the context of public transport planning. The concept of social welfare used here is broad it includes the utility of passengers, the financial performance of operators, and the externalities that affect non-users and society at large.

The chapter is organized into several core sections. It begins with a discussion of utility theory and social welfare functions, outlining how individual travel behavior is modeled and aggregated into societal outcomes (Section 2.2). This is followed by an in-depth look at fare planning models (Section 2.3), covering approaches ranging from simple revenue-maximizing strategies to complex multi-objective and equity-constrained formulations. Section 2.4 focuses on discrete choice models used to estimate travel demand, with particular attention to how these models capture heterogeneity in traveler preferences. Environmental concerns are addressed in Section 2.5, which examines how externalities such as emissions, congestion, and accident risk can be monetized and incorporated into the generalized cost of travel. Section 2.6 then turns to issues of equity, affordability, and social inclusion—highlighting how fare levels disproportionately affect women, low-income households, and marginalized groups. This is extended in Section 2.7, which explores the interaction between formal and informal transport systems, especially in cities like Dhaka where informal modes account for a large share of daily mobility but are often excluded from formal policy frameworks.

To provide real-world context, Section 2.8 presents a set of case studies from cities in the Global South Manila, Jakarta, Delhi, and Nairobi that have attempted to reform fare structures and service integration with varying degrees of success. These cases offer valuable lessons for Dhaka, particularly regarding targeted subsidies, digital fare integration, and institutional coordination.

Finally, Section 2.9 synthesizes the major gaps in the literature. While significant progress has been made in modeling fare systems and travel behavior, there is limited integration of welfare, equity, and environmental objectives within a single analytical framework. There is also a lack of Dhaka-specific models that can address its dual formal–informal system, spatial inequalities, and social constraints. Addressing these gaps is essential for designing transport systems that are not only financially and operationally sustainable but also inclusive and socially just.

**2.2 Theoretical Foundations of Social Welfare in Transport**

2.2.1 Utility Theory and Random Utility Maximization (RUM)

At the core of transport choice modeling lies the principle that each individual makes travel decisions to maximize personal utility. When a traveler is presented with a finite set of alternatives, denoted by , the choice made reflects the option that offers the highest perceived benefit. This benefit, or utility, can be broken down into two components: a systematic part ​, which captures observable attributes such as travel time, fares, and comfort, and a random component ​, which accounts for unobserved factors, taste variations, and measurement errors. Within the Random Utility Maximization (RUM) framework, the utility associated with an option is expressed as:

(Equation 2.1)

When the random components ​ follow an independent and identically distributed Type I extreme value distribution, the resulting probability that an individual selects alternative iii over all others takes a closed-form expression known as the logit model, introduced by McFadden [1]. This probability is given by:

The scale parameter governs the variance of the error terms. While the logit model offers computational simplicity, it assumes independence among alternatives. To address this limitation, Train (2009) expands the RUM framework to more general cases, including probit, nested logit, and mixed logit models, allowing for more flexible substitution patterns and correlation structures among choices [2].

2.2.2 Social Welfare Functions and Equity-Adjusted Utility

The concept of social welfare in transport extends beyond individual utility to capture the broader societal outcomes of transport systems. A social welfare function (SWF) combines the utilities of all individuals in the population while accounting for system-wide costs and externalities. Two classical approaches are commonly discussed. The utilitarian approach sums the net utility of all individuals, subtracting total system costs C and externalities E, expressed as:

,

In contrast, the Rawlsian approach emphasizes the utility of the worst-off member of society, formalized as:

In practical transport modeling, the utilitarian framework is often adapted with equity weights ​ that assign greater importance to specific individuals or groups based on income, accessibility needs, or vulnerability. External costs are monetized and integrated into the welfare objective, leading to a more nuanced formulation:

(Equation 2.2)

This formulation allows planners to prioritize both efficiency and fairness. Vickrey (1969) and Small (2012) have been instrumental in formalizing welfare optimization in transport by advocating for the internalization of external costs and proper valuation of user benefits [4][5]. Ortúzar and Willumsen (2011) further elaborate on approaches that incorporate distributional weights or equity constraints, ensuring that disadvantaged groups receive a minimum level of benefit within the planning process [3].

2.2.3 Externalities and Market Failures in Transport

Transport systems inevitably generate a range of externalities congestion, air pollution, noise, road accidents, and greenhouse gas emissions that are often not reflected in market prices. These unpriced consequences lead to inefficiencies known as market failures. To correct them, economists have proposed pricing instruments that align private costs with social costs. A common approach involves setting user charges equal to marginal external costs, known as Pigouvian pricing. The generalized cost of a trip from origin i to destination j can be modeled as:

​

(Equation 2.3)

* is the private fare;
* is travel time valued at €/unit;
* is emissions or other externality metric monetized at €/unit.

This framework allows transport planners to incorporate time, environmental burden, and monetary costs into a single, comprehensive cost metric.

Pigou (1920) first articulated the idea of taxing activities that generate negative externalities to bring private behavior in line with the social optimum [6]. Building on this foundation, Small (2012) proposed more refined policy tools, such as peak-hour congestion pricing and location-specific charges, that better reflect the varying impacts of different travel behaviors and modes [5]. The EU Publications Office (2020) provides updated guidelines and standardized values for estimating the costs of externalities like CO₂ emissions, PM₂.₅ particles, and urban noise, which are crucial for calibrating effective pricing mechanisms in urban transport systems [7].

By combining the theoretical models presented in Equations 2.1 through 2.3 within a welfare optimization framework, transport planners can design policies that simultaneously address economic efficiency, environmental responsibility, and social fairness. This integrated approach allows for more holistic decision-making in urban transport planning.

2.3 Fare Planning Models

2.3.1 Revenue, Profit, and Demand Maximization Models

Early models of fare planning were largely built on simplified representations of passenger behavior, typically using linear or constant-elasticity demand functions. These models aimed to set fares in a way that fulfilled certain objectives, such as maximizing revenue, ridership, or achieving a break-even operating condition. Nash (1978), for example, models the fare-setting problem of a monopolistic bus operator as one of maximizing passenger-miles subject to a financial constraint. The model is expressed as 0 = F·Q + B – C(V) where F is the fare per passenger-mile, Q the patronage, B the subsidy, and C(V) operating cost as a function of vehicle-miles V. By solving the first-order conditions, the model identifies optimal fare and frequency levels that meet revenue or demand targets.

Glaister and Collings (1978) extend this approach by introducing a lower bound on passenger-miles into a profit-maximization framework. They demonstrate that this formulation is mathematically dual to the problem of maximizing patronage within a fixed budget. De Borger et al. (1996) further refine the modeling approach by incorporating both fixed and variable public transport costs into a detailed simulation calibrated with Belgian data. Their model uses linear demand functions estimated from elasticity values and generates fare structures that balance marginal social cost and average revenue across different subsidy regimes [1][2][3].

All three approaches can be generalized within a single mathematical form:

where are fare parameters (e.g.\ flat, distance-, or zone-tariff levels), the resulting ticket price, and the induced demand for travel choice between and .[[4]](#fn4)

2.3.2 Bilevel and Nonlinear Optimization Approaches

While single-level models are analytically convenient, they often overlook the distinct objectives and behaviors of service operators and travelers. Bilevel optimization frameworks offer a more realistic representation by explicitly modeling the interaction between fare-setting authorities (at the upper level) and users (at the lower level), whose choices follow behavioral rules derived from discrete-choice theory.

Borndörfer et al. (2012) incorporate a logit-based discrete-choice demand function into a bilevel nonlinear programming model. In this formulation, the upper-level problem sets fares x to optimize revenue or profit, while the lower-level problem models individual travel choices using a logit formula:

where is the deterministic utility (incorporating price disutility), a scale parameter, and trip-frequency probability. Solutions require large-scale nonlinear programming with GAMS/Snopt, but yield locally optimal fare structures integrated with capacity constraints and subsidies. Lam and Zhou (2003) similarly propose bilevel logit models to set peak/off-peak and mode-specific fares in multimodal systems, solved via heuristic descent.[[5]](#fn5)[[6]](#fn6)Although computationally intensive, these methods yield locally optimal solutions that are consistent with both user response and operational constraints. Their approach uses heuristic methods to solve for fare structures that reflect both peak and off-peak demand, capturing behavioral shifts across different service conditions [5][6].

2.3.3 Multi-Objective and Equity-Constrained Fare Models

Traditional fare models that focus solely on financial performance often neglect important social goals such as accessibility, affordability, and equity. Recent advances have incorporated these concerns into multi-objective models that jointly consider economic and distributional outcomes.

Schöbel and Urban (2024) propose a bi-objective optimization model that simultaneously maximizes fare revenue and total ridership. Their model distinguishes user groups by willingness-to-pay and generates Pareto-efficient fare structures under both flat and distance-based tariffs. The analysis identifies trade-offs between equity and efficiency, demonstrating that fare policies can be designed to reflect social priorities while maintaining financial viability [7].

Sun and Schönfeld (2015) develop a time-dependent welfare model that incorporates operator profit and consumer surplus into the objective function:

The model includes constraints on fleet size and vehicle capacity in each period g, and accounts for elastic demand that varies across time and space. They find that the optimal fare and headway levels are highly sensitive to the regulatory and subsidy environment, and that dynamic pricing where fares vary over time can avoid inefficient cross-subsidies between time periods. Their findings emphasize the importance of coordinated pricing and service planning to achieve long-term welfare gains under practical operational constraints [8].

Together, these three categories simple single-level maximization models, bilevel nonlinear formulations grounded in user behavior, and multi-objective approaches that incorporate social equity represent the current landscape of fare planning theory. They offer a comprehensive toolkit for designing pricing policies that balance financial sustainability, passenger demand, service equity, and environmental impact. By integrating these diverse models, transport planners are better equipped to navigate the complex trade-offs inherent in public transport systems, particularly in rapidly urbanizing and resource-constrained settings.

2.4 Discrete Choice Modeling in Public Transport

2.4.1 Multinomial and Nested Logit Models

Discrete choice models provide a foundational framework for analyzing travel-mode selection in public transport systems. These models assume that each traveler faces a finite set of alternatives, such as private car, bus, or rail, and chooses the option that maximizes personal utility. The utility associated with each alternative is represented as:

Discrete choice models of travel-mode selection assume that each traveler faces a finite set of alternatives (e.g., car, bus, rail) and assigns each alternative a utility

where is the observable (deterministic) component—typically a linear function of fares, travel times, and other attributes—and is an unobserved stochastic term representing idiosyncratic tastes (McFadden & Train, 1978;[[1]](#fn1)).

When the random components ​ are assumed to follow an independent and identically distributed Gumbel (Type I extreme value) distribution, the resulting model is known as the Multinomial Logit (MNL) model. The probability that individual n selects alternative i is given by:

(Equation 2.4.1)

Here, μ is a positive scale parameter that is inversely related to the variance of the unobserved component ​ [2].

Although the MNL model offers computational simplicity and closed-form choice probabilities, it has a well-known limitation its Independence of Irrelevant Alternatives (IIA) property. IIA implies that the relative odds of choosing between any two alternatives remain unchanged by the presence or characteristics of other alternatives. This assumption often leads to unrealistic results, such as in the “red bus/blue bus” paradox, where the addition of a nearly identical option disproportionately reduces the probability of choosing either of the original ones.

To address this issue, the Nested Logit model introduces a hierarchical structure that groups similar alternatives into “nests,” allowing for correlation in the unobserved utility components within each group. Each alternative belongs to a unique nest, indexed by alternatives are grouped into nests . Then

where

and

with inclusive value

and is a nesting parameter controlling within‐nest correlation[[3]](#fn3). When every , the nested logit reduces to MNL; when , choice within a nest becomes deterministic and only the nest‐level choice is stochastic.

The nested logit model significantly enhances flexibility by relaxing the IIA assumption and allowing for correlation between similar alternatives. This is particularly useful in transport applications where different modes share common characteristics. For instance, buses and metro systems may both be forms of public transport with overlapping service attributes, while air travel may be segmented into economy and business classes. By capturing these within-group similarities, nested structures yield more realistic cross-elasticities and more accurate behavioral predictions. Forinash and Koppelman (1993) illustrate this with empirical models that group public transport modes and premium travel services into coherent nests, improving both model fit and policy sensitivity [3].

2.4.2 Mixed Logit Models and Preference Heterogeneity

While the Multinomial Logit (MNL) and Nested Logit models have been widely used in transport choice modeling, they impose important limitations. Both rely on fixed coefficients across individuals and restrictive substitution patterns due to the Independence of Irrelevant Alternatives (IIA) property. This means that all travelers are assumed to have identical sensitivities to travel time, cost, and other attributes. However, in real-world settings—particularly in diverse urban environments—individuals vary considerably in their preferences and travel behavior. The Mixed Logit model, also known as the Random Coefficients Logit, addresses these limitations by allowing utility parameters to vary randomly across the population, thus capturing unobserved heterogeneity in preferences (Train, 2009) [1].

In a Mixed Logit specification, the utility of traveler for alternative is

where is a vector of observed attributes (fares, travel times, comfort, etc.) and is a vector of traveler‐specific coefficients drawn from a continuous distribution with population parameters . The random term is assumed i.i.d.\ Gumbel.

The Mixed Logit choice probability is an integral over the distribution of :

(Equation 2.4.2)

Since this integral cannot generally be solved analytically, simulation techniques are used for estimation typically employing Halton sequences or other quasi-random draws to approximate the integral efficiently. The choice of distribution is flexible, with common specifications including normal, log-normal, uniform, and triangular forms. The flexibility of these distributions allows the model to capture skewness, heavy tails, or bounds on coefficients, depending on the behavioral context.

Mixed Logit models offer several important advantages. First, they allow for individual-level variation in sensitivity to key variables, such as price, time, comfort, or safety, thereby producing more realistic demand forecasts. Second, because substitution patterns are determined by the distribution of coefficients rather than fixed parameters, Mixed Logit avoids the restrictive IIA assumption and accommodates more complex correlations in choice behavior. Third, under broad conditions, Mixed Logit can approximate any random utility model, making it one of the most general and powerful tools in discrete choice analysis [1].

The strengths of the Mixed Logit model are especially relevant in cities like Dhaka, where transport systems are characterized by a mix of formal and informal modes, wide income disparities, and heterogeneous travel needs. In such contexts, modeling the population as homogeneous leads to biased estimates and ineffective policy recommendations. For instance, Quddus et al. (2019) apply a Mixed Logit model to examine the factors influencing adoption of the Bus Rapid Transit (BRT) system in Dhaka. Their findings reveal substantial heterogeneity in how travelers value fare levels, safety, and travel time. In particular, cost coefficients followed a log-normal distribution, reflecting extreme sensitivity to fare changes among low-income passengers. The study also found that factors such as trip purpose and income level significantly influenced the likelihood of adopting BRT, underscoring the need for differentiated pricing and service strategies [2].

By allowing fare sensitivity, value of time, comfort preferences, and safety perceptions to vary across individuals, the Mixed Logit model delivers more accurate predictions of mode choice and more precise estimates of welfare impacts. This makes it especially valuable for evaluating fare reforms, subsidy schemes, or the introduction of new transit services in complex and unequal urban environments. In policy terms, the ability to model preference heterogeneity enables planners to better assess how different population segments respond to pricing or service changes, facilitating more equitable and efficient transport systems.

2.4.3 Fare Optimization Formulations

Discrete choice models such as Multinomial Logit, Nested Logit, and Mixed Logit not only provide a behavioral foundation for understanding travel demand, but also serve as the analytical backbone for fare optimization in public transport systems. By linking user utility to observable fare structures and service attributes, these models allow operators to simulate how travelers respond to changes in pricing. This, in turn, enables the design of fare strategies that balance competing goals such as revenue generation, ridership maximization, equity, and environmental sustainability.

At the core of fare optimization is the objective to determine fare parameters—such as flat rates, distance-based tariffs, or peak/off-peak pricing—that maximize a specific welfare function. Depending on the planning goals, this welfare function can be purely financial (e.g., revenue or profit), social (e.g., total consumer surplus or accessibility), or a combination of both. The general form of the fare optimization problem, grounded in discrete choice-based demand estimation, is typically expressed as:

max⁡x∈P∑(s,t)∑i∈C′psti(x)⋅dsti(x)\max\_{x \in P} \sum\_{(s,t)} \sum\_{i \in C'} p\_{st}^i(x) \cdot d\_{st}^i(x)x∈Pmax​(s,t)∑​i∈C′∑​psti​(x)⋅dsti​(x)

Here, xxx represents the decision variables corresponding to fare levels or structures, psti(x)p\_{st}^i(x)psti​(x) is the fare charged for travel alternative iii between origin sss and destination ttt, and dsti(x)d\_{st}^i(x)dsti​(x) is the demand for that alternative, derived from a discrete choice model. The feasible set PPP includes operational constraints, such as fare caps, subsidy limits, and capacity restrictions.

When demand dsti(x)d\_{st}^i(x)dsti​(x) is specified through a logit model—such as in the Mixed Logit or Nested Logit framework—the fare optimization problem becomes a nonlinear and often non-convex program. Solving such problems requires specialized numerical techniques. For example, simulation-based optimization methods, such as simulated annealing or genetic algorithms, are frequently employed when the demand model includes random coefficients or lacks closed-form derivatives. In bilevel formulations, the upper level maximizes revenue or welfare while the lower level models traveler response via a discrete choice function. This structure reflects the strategic interaction between operators setting fares and users choosing modes or routes accordingly.

Moreover, fare optimization often incorporates equity considerations, either through explicit constraints (e.g., maximum fares for low-income groups) or through the use of weighted welfare functions that give higher importance to disadvantaged populations. This is particularly relevant in cities like Dhaka, where affordability remains a major barrier to access. For example, including equity weights wnw\_nwn​ in the objective function allows planners to prioritize social inclusion by accounting for varying levels of fare sensitivity and travel necessity across socioeconomic groups.

In advanced formulations, fare optimization is extended to dynamic settings, where fares vary over time or respond to real-time conditions such as congestion levels, vehicle occupancy, or energy costs. Time-of-day pricing models, for instance, aim to shift demand from peak to off-peak periods, thereby improving capacity utilization and reducing externalities. These models can be embedded within a Mixed Logit framework to accurately reflect how different user groups respond to temporal fare variations.

In practice, the success of fare optimization depends not only on the mathematical rigor of the model but also on the quality of the input data and the robustness of demand estimates. Discrete choice models calibrated on rich, disaggregated data—such as household travel surveys or smart card transaction logs—enable more precise forecasting of traveler responses. Furthermore, sensitivity analyses are often conducted to examine how changes in fare elasticity or income distribution affect the optimal solution, thereby increasing the credibility and resilience of policy recommendations.

In sum, fare optimization formulations serve as a crucial bridge between theoretical travel behavior modeling and practical transport planning. When grounded in discrete choice models that capture user heterogeneity, these formulations allow for the design of data-driven, context-sensitive, and socially responsible pricing strategies. As transport systems grow increasingly complex and resource-constrained, integrating fare optimization within a behavioral framework becomes essential for delivering services that are not only financially viable but also equitable and sustainable.

2.5 Environmental Externalities and Social Cost Internalization

Urban transport systems generate significant negative externalities, particularly when individual travelers do not directly pay for the full social costs associated with their trips. Among the most critical of these are emissions from fossil fuel combustion, traffic congestion, and road accidents. These external costs lead to market failures when left unaddressed, resulting in suboptimal outcomes for society as a whole. A widely used policy approach to correct this is to internalize these externalities through shadow pricing—assigning monetary values to each external effect and incorporating them into the generalized cost of travel. This leads to an adjusted cost formulation expressed as:

GC=Fare+α⋅TravelTime+β⋅Emissions+γ⋅AccidentRisk+δ⋅CongestionDelayGC = \text{Fare} + \alpha \cdot \text{TravelTime} + \beta \cdot \text{Emissions} + \gamma \cdot \text{AccidentRisk} + \delta \cdot \text{CongestionDelay}GC=Fare+α⋅TravelTime+β⋅Emissions+γ⋅AccidentRisk+δ⋅CongestionDelay

(Equation 2.5.1)

This extended cost function allows planners and policymakers to evaluate and modify fare structures, taxes, and subsidies in a way that reflects the full social cost of travel behavior.

Emissions are one of the most extensively studied externalities. The combustion of fossil fuels by motorized vehicles emits both local air pollutants—such as carbon monoxide (CO), nitrogen oxides (NOₓ), and particulate matter (PM)—and global greenhouse gases like carbon dioxide (CO₂). These emissions have well-documented impacts on public health and climate change. To monetize these impacts, researchers combine pollutant-specific damage costs per kilogram with vehicle emission rates per kilometer. For instance, the European Union applies shadow prices of €5 to €50 per 100 grams of CO₂, depending on the context and policy scenario (EU Publications Office, 2020) [2]. In the case of nitrogen oxides, which have severe respiratory and environmental effects, marginal social costs can reach up to €200 per ton in urban areas (Profillidis et al., 2014) [3].

Congestion represents another major externality, especially in dense urban environments where road capacity is limited. When a road segment is nearing saturation, each additional vehicle causes incremental delays for others. This delay can be valued using the marginal value of time, often estimated between €10 and €30 per hour for urban commuters. The marginal congestion cost is then calculated by multiplying this value of time by the extra travel time induced per vehicle-kilometer. In congested arterial roads, these marginal costs typically range from €0.05 to €0.30 per vehicle-kilometer (Small, 2012) [4].

Accident risk is also a substantial but less visible cost borne by society. Traffic crashes result in fatalities, injuries, property damage, and productivity losses. In economic evaluations, the value of statistical life (VSL) is commonly used to estimate the cost of fatal accidents. Within the European Union, VSL estimates range from €3 million to €5 million per fatality. When translated to a per-vehicle-kilometer basis, these values result in marginal accident costs of approximately €0.01 to €0.05, depending on road conditions, vehicle types, and the urban context [2].

Incorporating these shadow prices into the generalized cost of travel enables the development of pricing instruments that adhere to the "polluter pays" and "user pays" principles. These instruments may take various forms: per-liter fuel taxes (which act as carbon pricing tools), time-of-day congestion charges, distance-based road pricing schemes, or differentiated fares based on environmental impact. When properly calibrated, such policies can nudge users toward more sustainable transport modes, reduce peak-hour congestion, and internalize the environmental and safety costs that are otherwise ignored in private travel decisions.

2.6 Transport Equity, Affordability, and Inclusion

Ensuring equitable access to transport is central to socially inclusive urban mobility planning. Equity in public transport requires recognizing that different population groups—especially low-income households, women, and other marginalized communities—face disproportionate financial, spatial, and safety-related barriers. This section explores both the economic and social dimensions of transport equity, focusing on affordability metrics, income elasticity of demand, and gender-sensitive fare policy design.

2.6.1 Affordability Metrics and Income Elasticity

Transport affordability is typically assessed by measuring the proportion of household income allocated to travel expenses. When this share surpasses a defined threshold—commonly 10% or 15%—households are considered to be in “transport poverty,” where cost burdens restrict their ability to travel for work, education, healthcare, or social needs [1]. For low-income households, even small fare increases can translate into significant mobility losses. Serebrisky et al. (2009) found that in several Latin American cities, the poorest quintile often spends up to 20% of household income on transport, intensifying poverty cycles and limiting economic participation [2].

Low-income travelers tend to exhibit high price elasticity of demand—meaning their travel behavior is highly responsive to fare changes. As a result, when fares exceed affordable thresholds, these groups often reduce their trips or shift to informal or less safe modes. Dewita, Chen, and Zhu (2020), in their comparative study of Jakarta and Metro Manila, show how progressive fare interventions can reverse this trend. By combining targeted discounts with service improvements, they achieved a 25% to 40% increase in transit usage among the lowest-income quintile, while keeping transport costs under 10% of income [3]. Their logistic regression results further revealed that for every 1% reduction in the effective fare burden, the likelihood of low-income individuals using public transport rose by a factor of 0.8 (p < 0.01).

These findings highlight the critical role of affordability-oriented fare design—not only in expanding ridership, but also in reducing spatial exclusion and improving access to essential services for vulnerable groups.

2.6.2 Gender and Social Inclusion in Fare Policy

Women face a unique set of mobility challenges shaped by both socioeconomic constraints and travel safety concerns. Lower incomes, household caregiving responsibilities, and complex trip-chaining patterns often limit their travel choices. Additionally, fear of harassment or assault discourages travel, particularly during off-peak hours or on overcrowded routes. To address these issues, several cities have implemented targeted interventions combining fare relief, safety enhancements, and dedicated services.

One notable example is Delhi’s fare-free public bus travel (FFPT) program for women, launched in 2019. Over four years, the proportion of female bus users rose from 33% to 42%, while nearly 28% of surveyed women reported saving ₹500 or more per month—equivalent to as much as 8% of their household income [4]. This increase in independent mobility has been associated with improved access to employment and education, along with a reduction in dependency on male escorts for travel. Similar programs in Cairo and Rio de Janeiro, which introduced women-only metro carriages, have reported reductions in harassment incidents and improved perceptions of comfort and safety [5].

Beyond dedicated services, concessional fare programs also play a vital role in promoting gender equity. Mumbai’s discount passes for women and students, offering up to 50% reductions on monthly fares, have led to a 15% increase in female ridership and a 12% rise in off-peak travel among eligible groups [6]. These outcomes suggest that lower fares, especially during off-peak hours, can alleviate both financial and scheduling constraints that disproportionately affect women.

Infrastructure design and safety measures further contribute to inclusive mobility. Goodman et al. (2014) found that women are more likely than men to avoid poorly lit or overcrowded vehicles and stations. Interventions such as improved lighting, visible security presence, and staff assistance significantly reduce perceived risk—by up to 30% in some cases—and increase the willingness to travel during off-peak hours [7]. Similarly, Ahmed et al. (2021) emphasize the importance of perceived social support in transit environments. Their study showed that a combination of fare concessions and social presence—such as visible staff and other passengers—led to a 20% improvement in social inclusion scores among older women [8].

In sum, promoting equity in urban transport requires an integrated approach that combines financial accessibility with physical and psychological safety. Fare relief, women-specific services, and safer infrastructure all contribute to making public transport more inclusive. However, these measures must be accompanied by continuous monitoring of usage patterns, affordability indicators, and safety incident data to ensure that policy goals are being met and to guide further refinements.

2.7 Formal versus Informal Public Transport: Equity and Access

The urban transport landscape of Dhaka is defined by a dual structure comprising formal mass transit—such as Metro Rail, Bus Rapid Transit (BRT), and regulated bus services—and a sprawling informal sector dominated by rickshaws, minibuses, and other para-transit modes. While both systems play crucial roles in ensuring citywide mobility, their interaction often results in spatial mismatches and access inequalities, particularly for vulnerable populations.

2.7.1 The Scale of Informal Modes

Informal transport, especially three-wheelers like cycle-rickshaws and battery-powered rickshaws, plays a central role in Dhaka’s mobility ecosystem. These modes serve as the primary means of last-mile connectivity in dense and narrow urban areas where formal vehicles cannot operate efficiently. Ahasan and Kabir (2021) report that rickshaws and e-rickshaws account for over 40% of intra-city trips in Dhaka, despite occupying a marginal share of road infrastructure. In contrast, formal bus and mass transit systems carry about 44% of trips, despite their dominant physical footprint [1].

This trend is even more pronounced in medium-sized cities such as Rangpur, where Pramanik and Rahman (2020) find that e-rickshaws serve as the mainstay of public transport, handling approximately 74% of all passenger trips [2]. These modes provide low-cost, door-to-door services in areas poorly served by conventional bus routes, making them indispensable for daily travel among lower-income groups.

2.7.2 Spatial Coverage and Mismatch

A major challenge facing Dhaka’s transport system is the spatial disconnect between formal infrastructure investment and the actual distribution of travel demand. Formal mass transit investments have been concentrated along arterial corridors, often leaving peripheral zones and inner-city neighborhoods underserved. As a result, residents of these areas face long walking distances or are compelled to rely on multiple, often uncoordinated transfers between informal and formal services.

Policy measures such as banning rickshaws from major thoroughfares—intended to reduce congestion—have unintentionally deepened access barriers for many users. Women, the elderly, and low-income workers, who depend heavily on informal modes for their flexibility and proximity, are particularly affected. These restrictions force them to make fragmented journeys involving costly and time-consuming mode changes [3].

Hossain et al. (2023) attribute this spatial mismatch to institutional fragmentation across Dhaka’s transport governance landscape. They note that the absence of coordination among the BRT authority, metro company, and municipal agencies has resulted in overlapping services, inconsistent route planning, and inefficient infrastructure deployment [4]. One consequence is that MRT Line 6, for instance, bypasses densely populated informal settlements and lacks integrated feeder services to connect with surrounding neighborhoods.

2.7.3 Equity Implications

The widespread use of informal modes underscores their value to underserved communities. With fares 30–50% lower than formal buses, informal transport offers an affordable and accessible mobility solution for low-income households. Their flexibility—enabling door-to-door travel without fixed schedules—caters especially well to time-sensitive and labor-oriented travelers [2].

However, the informality of these modes also introduces trade-offs. Passengers often face inconsistent service quality, safety concerns, and exposure to unregulated operators. Meanwhile, formal mass transit—although more efficient in terms of speed and capacity—remains financially and physically inaccessible for many city residents. This duality has resulted in a fragmented system that perpetuates inequality rather than resolving it.

System-level assessments by Ahasan and Kabir (2021) reveal that Dhaka’s formal bus services suffer from low system and network efficiency, yet exhibit high utilization efficiency—indicating chronic overcrowding and operational strain [1]. At the same time, Pramanik and Rahman (2020) emphasize the socioeconomic importance of informal e-rickshaw operations, not only for passengers but also for drivers who depend on them for livelihood [2]. Banning or sidelining such services without providing alternatives risks undermining both access and income stability for large segments of the population.

2.7.4 Towards Integrated Solutions

Addressing these equity challenges requires a strategic approach that bridges formal and informal transport systems through institutional coordination, infrastructure design, and policy innovation. First, effective coordination among planning agencies is critical to ensure that informal modes are not excluded but rather integrated as feeders to mass transit nodes [4]. Metro and BRT stations should be designed with designated stops for rickshaws and minibuses, facilitating smooth and safe transfers while reducing travel time penalties [1].

Second, regulatory frameworks must evolve to support licensing, training, and quality standards for informal operators, thereby enhancing safety without sacrificing access [2]. Recognizing informal services as legitimate contributors to urban mobility allows for structured improvements without displacing existing networks.

Finally, targeted subsidies and fare integration policies can make formal systems more inclusive. These may include reduced fares for low-income travelers, single-ticket systems across modes, or shared revenue models that ensure financial sustainability for both formal and informal operators.

By embracing these integrated strategies, Dhaka can move toward a more cohesive and equitable urban mobility system—one that values both the accessibility of informal services and the efficiency of formal mass transit. Reducing spatial mismatches and recognizing the complementary strengths of each mode are essential steps in advancing transport equity in one of the world’s most densely populated cities.

2.8 Case Studies: Global South Perspectives

The rapid pace of urbanization in cities across the Global South has driven both experimentation and tension in public transport fare and service reforms. While the challenges of affordability, informality, and integration are widely shared, local strategies often yield varied outcomes depending on governance, institutional coordination, and socio-economic context. This section presents four illustrative case studies—Manila, Jakarta, Delhi, and Nairobi—that offer actionable insights for Dhaka’s evolving transport policy landscape.

Manila: Fare Reform and Income Elasticity

Doroy et al. (2017) conducted a logit-based analysis of travel mode choices in Metro Manila, highlighting how income plays a pivotal role in shaping mode preferences. Their findings show that with each 1% increase in household income, the odds of switching from public transport to private modes (especially cars) rise by 1.15 times [1]. Despite widespread congestion and public modes (bus, jeepney, rail, ferry) still serving over 80% of total trips, car ownership continues to rise, driven largely by unmet service expectations.

This underscores a key policy lesson: fare reforms alone are insufficient to retain lower-income riders in public transport systems. Without reliable service frequency, safe infrastructure, and broader affordability mechanisms—such as income-targeted subsidies—households will continue to opt for private alternatives as their economic conditions improve. Manila’s experience points to the need for multi-pronged strategies that address both fare burden and service reliability.

Jakarta: Jak Lingko Integration

Jakarta launched its fare and service integration initiative, Jak Lingko, in 2018, aiming to bring together fragmented public transport systems under a unified platform. The integration covered TransJakarta BRT, MRT, LRT, commuter rail, and informal feeder minibuses (mikrotrans) [2]. The reform included a capped fare policy of IDR 10,000 for trips completed within a three-hour window and introduced key digital tools—a common fare card, a trip-planning app, and later QR-code payments and account-based ticketing systems [3].

Between 2018 and 2022, these upgrades led to a 25% increase in multimodal transfers and significantly reduced first- and last-mile gaps. The phased approach allowed institutional learning and rider adaptation while physical station upgrades and feeder alignment improved user experience. Jakarta’s model demonstrates how fare technology, when combined with physical integration and institutional backing, can promote seamless travel even in systems with strong informal components.

Delhi: Free Bus Travel for Women

In October 2019, the Delhi government introduced a fare-free policy for women on public buses, targeting both affordability and social inclusion. Over the following four years, the initiative resulted in a 20% increase in female ridership and average monthly savings of INR 2,300—equivalent to 8% of household income for many [4]. Mixed-method evaluations reveal that 23% of existing women riders increased their trip frequency, while 15% of previous non-users began using the service.

The success of this policy stems not only from the fare exemption itself but also from complementary safety measures, such as CCTV-equipped buses, dedicated seats, and improved service frequency. The Delhi case offers a clear lesson: well-targeted concessions can generate substantial equity and welfare gains, especially when paired with structural improvements in service safety and accessibility.

Nairobi: Challenges in Paratransit Regulation

In Nairobi, efforts to regulate the city’s informal minibus network (matatus) have met with limited success. Reforms such as the “Michuki Rules” in 2004 and subsequent licensing mandates aimed to formalize operations, improve safety, and ensure service quality. However, Kamau and Njenga (2017) and subsequent SSRN analyses (2024) reveal that heavy-handed regulation, implemented without sufficient planning or financial support, resulted in rent-seeking behavior, high compliance costs, and widespread non-compliance [5].

The Nairobi experience highlights the risks of attempting to reform informal systems through top-down regulation alone. In the absence of an integrated urban mobility authority and financing support for operators (e.g., vehicle credit, insurance, revenue-sharing mechanisms), even well-intentioned reforms can backfire. Sustainable reform of paratransit must involve coordination across institutions, infrastructure upgrades, and support mechanisms that allow informal operators to transition gradually into the formal system.

Relevance for Dhaka

These case studies offer several important takeaways that can inform Dhaka’s public transport strategies:

* Targeted Subsidies: As shown in Manila, household income levels significantly influence mode choice. Dhaka can benefit from introducing income-linked subsidies or fare relief programs to retain low-income riders and prevent modal shift to private vehicles.
* Digital Fare Integration: Jakarta’s Jak Lingko system demonstrates the power of unified fare cards and mobile trip planners in promoting multimodal travel. For Dhaka, especially as Metro Rail and BRT expand, fare and route integration with informal feeders will be essential to reduce transfer penalties.
* Equity-Centered Fare Policy: Delhi’s fare-free travel for women showcases the effectiveness of targeted concessions in promoting social inclusion. Similar policies in Dhaka—perhaps aimed at women, students, or senior citizens—could significantly improve mobility outcomes for vulnerable populations.
* Institutional Reform: Nairobi’s challenges emphasize the need for holistic reform frameworks. Dhaka must move beyond isolated regulations and work toward establishing a dedicated urban mobility authority that can coordinate licensing, financing, infrastructure, and service planning across both formal and informal modes.

In summary, while each city’s context differs, these examples offer Dhaka valuable guidance in crafting policies that balance affordability, equity, and efficiency. By learning from the successes and failures of peer cities in the Global South, Dhaka can design transport reforms that are both context-sensitive and socially inclusive.

2.9 Identified Gaps in the Literature

Despite considerable progress in fare modeling, discrete choice frameworks, and multi-objective network design, several persistent gaps remain in the literature, particularly concerning the integration of welfare, equity, and environmental concerns, the specificity of models to complex cities like Dhaka, and the availability of reliable data to represent informal transport systems.

First, there is a clear lack of comprehensive integration between welfare optimization, equity considerations, and environmental externalities. Most existing fare-planning models prioritize economic goals—such as maximizing revenue or demand—while treating social and environmental impacts as secondary, if at all. For example, Borndörfer et al. (2012) propose bilevel optimization methods that address capacity and budget constraints while maximizing system performance, yet they do not include measures such as fare burden inequality or environmental shadow pricing in their objectives [1]. Similarly, although Huang et al. (2016) introduce OD-based nonlinear fare models with a focus on distributional fairness, their approach does not account for emissions or broader system-wide welfare [4]. This narrow focus can lead to policy recommendations that inadvertently sacrifice environmental sustainability or distributive justice for financial efficiency, without clearly assessing the trade-offs involved.

Second, there is an absence of multi-objective bilevel frameworks tailored to the urban transport context of Dhaka. Existing models typically assume stable, formalized networks with predefined routes and fare structures. However, Dhaka’s transport system is deeply hybridized—formal transit modes like Metro Rail and BRT coexist with informal operators such as rickshaws and minibuses, which together serve a large share of the population. Schöbel and Urban (2024) demonstrate multi-objective approaches that balance operator revenue and user ridership in generalized urban settings, but such frameworks remain under-adapted to cities with strong informal transport sectors and sharp socioeconomic inequalities [3]. A city-specific model for Dhaka would need to consider flexible fare regimes (flat, zonal, or distance-based), service coordination between formal and informal operators, and equity safeguards like maximum fare burdens for low-income households. It would also need to integrate environmental costs—such as air pollution and carbon emissions—into pricing decisions. Such a model would enable planners to jointly optimize fare policies, service frequencies, environmental targets, and social welfare, all while capturing the unique challenges posed by Dhaka’s unstructured and rapidly evolving transport ecosystem.

Third, the lack of high-quality, representative data remains a fundamental barrier to developing robust and realistic models for Dhaka. In contrast to data-rich contexts like Western European cities, where origin-destination matrices, boarding data, and detailed cost estimates are readily available, Dhaka’s transport data landscape is sparse and fragmented. Most informal-sector operations—particularly rickshaws and small minibuses—operate without formal registration or electronic ticketing, leaving large segments of travel behavior undocumented. Ahasan and Kabir (2021) estimate that these modes account for over 40% of daily trips in the city, yet they are rarely included in transport models due to measurement gaps [5]. Without accurate estimates of fares, travel times, or user profiles across the informal network, policy simulations may misjudge mode shifts, cost burdens, or equity outcomes.

Addressing these gaps will require a deliberate effort to develop Dhaka-specific modeling frameworks that go beyond conventional fare optimization. A comprehensive bilevel, multi-objective model—combining revenue, ridership, environmental costs, and distributional equity—could provide a foundation for inclusive transport planning. However, this must be supported by improved data systems. Smartcard adoption in formal modes, mobile-based user surveys in informal networks, and systematic fare and cost tracking are essential steps to ground future models in reality. Only then can policymakers design pricing and service strategies that are equitable, environmentally responsible, and financially sustainable in Dhaka’s complex urban mobility environment.