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Bridging the Divide of Formal and Informal Transit in Urban Areas - Considering Multidimensional Aspects of Sustainability

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Public transport in cities across the developing world is fundamentally shaped by the dualism of formal and informal services. Informal transport modes, including mini busses, shared taxis, and auto-rickshaws, are not merely supplementary but are essential components of the urban mobility ecosystem, providing critical connectivity for marginalized communities. Contemporary scholarship advocates for a multifaceted evaluation of these systems to capture their full socio-economic, environmental, and operational impact. This paper conducts a systematic literature review to synthesize existing assessment frameworks for public transport. The findings reveal a significant gap: current methodologies often fail to integrate the core dimensions of sustainability—social, economic, and environmental—with emerging imperatives like climate resilience and comprehensive regulatory and technological considerations. By mapping the state of the art, this review underscores the necessity for a more holistic evaluation paradigm, focusing on frameworks that move beyond a simple formal-informal divide to foster comprehensive understanding and strategic integration.

Keywords: Transit System, Formal Transit, Informal Transit, Sustainability

Introduction:

Urban transit systems in developing cities are complex and dynamic, characterized by the interplay of formal and informal transit systems. While formal transport networks typically involve structured, regulated services, informal modes—such as shared taxis, mini busses, or vans—play a vital role in addressing mobility gaps, particularly in underserved areas and for low-income populations [1][2]. A significant literature gap exists in understanding the operational synergies and conflicts between these systems from an integrated planning perspective.

Recent research increasingly calls for a multidimensional assessment approach, acknowledging the socio-economic, environmental, operational, and planning implications of these systems to achieve sustainable urban transit solutions [3][4]. However, a critical gap remains, as most assessment frameworks fail to holistically integrate all sustainability dimensions. The effective assessment of these diverse transportation modes is essential for sustainable urban planning and policy development. This systematic literature review, therefore, aims to synthesize existing knowledge on assessment frameworks for both formal and informal transportation and identify the specific dimensions that are currently overlooked.

Problem Statement and Research Aim:

Urban transit systems have been studied in various research works. Although some studies have assessed this system in the context of sustainability, however, as yet, there are no studies that holistically capture various dimensions of sustainability (social, economic, technological, legal, and environmental). The aim of the research is Dual. Firstly, to establish the state of the art and also the knowledge gaps in connection to formal and informal urban transit system assessment to understand where the current state of art studies stands. Secondly, based upon this exploration, the paper will briefly portray a knowledge gap and multidimensional aspects that, if included, can render a more holistic framework regarding sustainable urban transit systems. The summary of the literature review is captured in the form of a matrix categorically in Table 2. The matrix objectively depicts that no literature has been found that captures sustainability along with its three dimensions of social, environmental, economic, and climate change, along with its two dimensions of adaptation and climate change, as well as resilience.

An assessment framework for transportation systems, encompassing both formal and informal modes, needs to consider a multitude of factors to provide a holistic view of their performance and impact. Such a framework should integrate various perspectives, including operational efficiency, socio-economic benefits, and regulatory compliance.

The objectives of this literature review are designed to systematically contribute to a deeper understanding of public transit assessment frameworks.

To identify and categorize the key dimensions and indicators used to assess formal and informal transit systems separately.

To critically analyze the extent to which existing frameworks facilitate an integrated assessment of the combined formal-informal transit ecosystem.

To pinpoint the overlooked dimensions and methodological limitations that prevent a comprehensive sustainability evaluation.

Methodology:

This research employed a systematic literature review to analyze existing knowledge on public transit assessment. The study specifically investigated formal and informal systems to identify gaps in current sustainability frameworks, including social, environmental, economic, technological, and legal dimensions. The review followed four structured phases:

Planning Phase:

We developed a comprehensive review protocol that defined:

Inclusion Criteria: Peer-reviewed studies (2010-2023) addressing assessment methodologies for formal/informal transit systems, with a focus on sustainability dimensions.

Exclusion Criteria: Non-empirical commentaries, studies without clear methodological frameworks, and publications not in English.

Search Strategy: We conducted systematic searches across Scopus, Web of Science, and Google Scholar using Boolean combinations of keywords: ("public transport" OR "transit") AND ("formal" OR "informal") AND ("assessment framework" OR "sustainability indicators") AND ("developing cities" OR "Global South").

Conducting the Review:

The search strategy was executed through:

Database Searching: Systematic searches across major academic databases

Two-Stage Screening: Independent title/abstract screening followed by full-text review

Reference Checking: Manual examination of citations in selected studies

Data Analysis and Synthesis:

The analysis involved:

Systematic data extraction using a standardized form

Documentation of assessment frameworks, performance indicators, and key findings

Comparative analysis of formal and informal transit evaluation approaches

Reporting:

Findings were presented through:

Structured presentation of results

Critical discussion of limitations and research gaps

Concise conclusions summarizing key insights

Public Transit Systems: Formal and Informal:

Transit refers to organized passenger transportation services that operate on predetermined paths, following scheduled timetables along designated stops. In fixed-route transit, vehicles travel along established corridors with little to no deviation, providing structured and predictable service. *"A structured system of transport services designed for collective passenger mobility, often operating on fixed routes and schedules* [5]*".*

Formal and Informal Transit:

Formal Transportation: While formal transport systems are often seen as the ideal for urban mobility, they are frequently inadequate or underdeveloped in many developing cities, particularly in their integration with existing transport modes [3]. There is a growing recognition of the need for integrated and multimodal transport planning [3].

Informal Transportation: In many developing cities, informal public transport plays a crucial role in filling the gaps left by insufficient formal systems, providing essential mobility for a significant portion of the population [6][4][1][2]. These systems are often characterized by their flexibility, responsiveness to demand, and ability to reach areas not served by formal transit [7]. They also provide livelihood opportunities for many [1]. However, informal transport can contribute to issues such as traffic congestion, pollution, and safety concerns [1] Some research even suggests that informal transport networks can self-organize efficiently, sometimes outperforming centrally planned formal systems [8]. The concept of "indigenous transport" has been proposed as an alternative way to conceptualize informality, acknowledging its local and vernacular qualities [9].

Multidimensional Assessment and Key Considerations:

The recent body of research on formal and informal transportation in developing cities employs various methodological approaches to capture the multifaceted nature of these systems. Studies often adopt a qualitative and quantitative assessment of the roles and characteristics of both formal and informal transport, utilizing case studies from diverse

urban contexts globally, including Latin America, Africa, and Asia [10][11]. A significant methodological trend involves systems thinking, viewing transport as an integral part of broader urban development and societal dynamics [12][13]. Researchers analyze the socio-economic impacts through studies on accessibility and equity, often focusing on marginalized populations [14][4]. Operational analyses are common, investigating routing, flexibility, and service provision of informal modes [7]. Furthermore, there is a growing emphasis on policy analysis and planning frameworks, exploring strategies for formalization, integration, and regulation [15][7]. Many studies also highlight the importance of data-driven approaches and technological integration to enhance mobility and facilitate multimodal transport planning [16].

Recent studies emphasize a multidimensional approach for assessing urban transportation, encompassing various aspects. Research on transportation assessment frameworks highlights the complexity of evaluating diverse transport systems. For formal transportation, assessment often revolves around established performance indicators, service quality metrics, and economic viability [17].

In the context of informal transportation, the literature emphasizes the unique challenges in assessment due to their often unregulated nature and diverse operational models [18]. Studies focus on understanding user perception, determining appropriate service quality measures, and addressing the lack of formal benchmarks and regulatory policies [19][18]. For instance, research on fixed-route shared motorized paratransit services has highlighted the need for specific prescriptions and measures for service quality assessment, distinct from those for bus transit, and the importance of considering operator earnings [18]. Furthermore, the sustainability, drivers' quality of life, and governmental regulation are investigated in relation to paratransit features and policy backgrounds [19].

Regulatory Framework:

Effective governance and regulatory frameworks are crucial for managing the complex interplay of transport systems. Research delves into the challenges of regulating informal transport, often characterized by its "indigenous" and self-organized nature [9][8]. Studies examine formalization processes, acknowledging that successful integration requires a deep understanding of local contexts and political realities [7]. Urban planning is viewed as intrinsically linked to transport, with studies exploring how planning frameworks can accommodate and steer the evolution of both formal and informal transport to achieve sustainable urban forms, particularly in contexts with limited enforcement of regulations [12][13][20].

Service Quality and User-Centric Metrics:

Assessing informal transportation systems presents a distinct set of challenges due to their often-unregulated nature and diverse operational models. Literature emphasizes the crucial role of user perception in determining service quality for paratransit services [19][18]. Unlike formal systems, a different set of prescriptions and measures is often required for their assessment, acknowledging differences in operation, organization, and ownership [18].

Studies highlight a need for improvements in areas such as reliability, proper fare structures, fixed routes and stops, and a better environment for passengers [19]. It is also evident that despite positive user attitudes towards safety and fare structure, operational shortcomings, such as congestion, can significantly impact the perceived quality of these services [19]. Furthermore, the financial sustainability of informal operators, particularly their earnings, is a critical consideration since these services typically do not receive government subsidies [18].

Infrastructure and Technological Integration:

The increasing availability of data and technological advancements offers new avenues for integrating and optimizing urban mobility. Research explores how data analytics

and mobile applications can facilitate multimodal travel, improve service efficiency, and enhance real-time information for users, particularly in low-income urban environments where traditional infrastructure might be lacking [16]. These technological enablers provide tools for better planning, management, and even for promoting innovative transport solutions that bridge the gap between formal and informal services.

Integration and Hybrid Systems:

A prominent theme is the paradigm shift from viewing informal transport as a problem to be eradicated to recognizing its potential for integration into a hybrid urban transport system [15]. Researchers propose various integration strategies, from formalizing informal services through licensing and regulation to designing new institutional frameworks that allow for co-existence and complementarity [7][11]. This involves a tactical planning approach that acknowledges the operational strengths of informal paratransit, such as route flexibility and demand responsiveness, and leverages them to complement fixed-route formal transit . The goal is to create a more resilient and efficient network by understanding how these systems can work together rather than in isolation [10].

A significant focus is on integrating informal transport into formal urban planning frameworks, rather than simply replacing it. This involves understanding the operational characteristics of both formal and informal modalities and designing effective management systems that recognize their complementary roles.

Sustainability Dimensions:

Multi-criteria decision aid methodologies emerge as promising tools for assessing integrated urban public transport systems. These methods can effectively account for diverse dimensions, including economic, technical, environmental, and social aspects, providing a comprehensive evaluation of interconnected transport networks [21]. Tools like the Index of Sustainable Urban Mobility (I_SUM) exemplify this approach, offering a means to assess overall mobility conditions and inform policy decisions by considering economic, social, and environmental indicators [22]. The importance of benchmarking is also highlighted, enabling cities to compare their performance in sustainable urban mobility and learn from best practices [22].

Environmental Sustainability:

Environmental impacts, including air pollution, noise, and carbon emissions, are critical considerations within a multidimensional framework. While informal transport, particularly older vehicles, can contribute to pollution, integrated planning seeks to mitigate these effects [1]. Conversely, research also explores the role of non-motorized transportation in achieving sustainable urbanization, recognizing its potential for environmental benefits and improved public health [23]. Future frameworks need to balance accessibility needs with ecological imperatives, potentially through modal shifts and vehicle fleet improvements.

The environmental impact of transport modes, including air and noise pollution, is an important factor in multidimensional assessments [1]. The promotion of sustainable mobility, including non-motorized transportation, is gaining traction [23].

Socio-Economic and Equity Dimensions:

The socio-economic impacts of transport are central to recent assessments. Informal transport often provides essential mobility for low-income residents, connecting them to employment, education, and healthcare, thereby contributing significantly to livelihoods and social inclusion [4]. However, concerns regarding safety, particularly for vulnerable road users like motorized two-wheeler riders, are also highlighted [24]. Frameworks increasingly emphasize addressing equity issues, particularly in ensuring access for the "last mile" or "first mile" where formal transport is lacking, to prevent social exclusion and enhance urban liveability [14]. The provision of transport also directly supports informal sector employment, a significant aspect in many developing economies [1].

Socio-economic Impacts: Research examines the socio-economic impacts of both formal and informal transport, including their contribution to livelihood, access to opportunities, and issues of equity [24][4]. Ensuring equitable access to transportation is a critical concern, especially in addressing first-mile and last-mile challenges that can lead to social exclusion.

Framework Formation:

Recent research moves towards a comprehensive understanding of urban transport by developing frameworks that consider the interplay between formal and informal systems across multiple dimensions. An assessment framework for transportation systems, encompassing both formal and informal modes, needs to consider a multitude of factors to provide a holistic view of their performance and impact. Such a framework should integrate various perspectives, including user satisfaction, operational efficiency, socio-economic benefits, and regulatory compliance.

Key elements for framework formation, drawing from existing literature, are given in the following table.

Table 1. Key Indicators for Public Transport Assessment

Indicators	Sub-indicators	Details
Regulatory Framework	Legislation	Transport laws, safety standards.
	Regulations	Traffic rules, emission norms, and fare control.
Assessment Parameters	Availability	Service frequency, coverage, and operating hours.
	Accessibility	Ease of reaching transit points (disabled-friendly, last-mile connectivity).
	Mobility	Speed, efficiency, congestion levels.
	Synchronization	Intermodal connectivity (bus-rail integration).
Add Sustainability Considerations	Environment	Emissions reduction, green corridors, and eco-friendly fuels.
	Economics	Cost-benefit analysis, fare, subsidies.
	Social	Public acceptance, employment generation, and equity impact.
Synchronization	Administrative Sync	Inter-department coordination (e.g., traffic police & transport authority).
	Temporal Sync	Schedule alignment (e.g., feeder buses with train arrivals).
	Geographical Sync	Seamless inter-city/cross-border transport linkages.

Assessment of Formal Transportation:

The review of literature on formal transportation assessment reveals a consistent focus on quantitative methods and established service quality metrics. Public transport service quality is frequently evaluated using multi-criteria models, such as the Analytical Hierarchy Process, which consider both user and expert opinions. Key factors often highlighted in these assessments include operational groups and infrastructure [17]. Measures like headway, frequency, and on-time performance are commonly used to gauge service efficiency. The Transit Capacity and Quality of Service Manual provides a framework for evaluating various transit attributes, including the assessment of routes and waiting times [17].

This suggests a potential disconnect between planned service standards and the experience of passengers. Benchmarking methods are also employed to assess public

transport services, often utilizing available data to estimate factors like the number of people reached within an acceptable walking distance and across different headway classes [17].

Towards an Integrated Assessment Framework:

The findings underscore the necessity of moving beyond assessments of formal and informal transportation towards a more integrated framework. The concept of sustainable urban mobility itself necessitates a broader planning perspective that considers the interdependencies of various transport modes [22]. Integration, in this context, encompasses various levels and aspects, fostering a holistic view of urban mobility [25].

This would involve developing new indicators that capture the synergistic effects of different transport modes and addressing the complexities of regulating and formalizing informal services to ensure consistent service quality and safety across the entire urban mobility spectrum. The challenges lie in harmonizing disparate data sources, establishing common performance benchmarks that account for the unique characteristics of each mode, and ensuring equitable access and service quality for all users.

Table 2. Synthesis of Literature on Sustainable Public Transport Indicators

Author	Year	Remarks
[26]	2018	Covers multimodal passenger transport, infrastructure, and governance; overlooks digital integration and legal frameworks.
[27]	2023	Focuses on passenger transport and sustainability; limited attention to freight and legal dimensions.
[28]	2018	Addresses road and rail public transit systems with governance aspects; neglects digital infrastructure and private partnerships.
[29]	2014	Explores public-private participation and accessibility in transit; it lacks focus on environmental sustainability.
[30]	2014	Examines multimodal public transport equity; omits freight and digital governance analysis.
[31]	2020	Investigates rail and road integration with environmental sustainability; overlooks legal and regulatory mechanisms.
[32]	2020	Analyzes passenger transport and road networks; limited discussion on legislation and digital frameworks.
[33]	2016	Covers formal and informal transit modes; lacks focus on governance and legal implications.
[34]	2016	Comprehensive study on accessibility, infrastructure, and sustainability; minimal discussion of digital governance.
[35]	2021	Addresses multimodal transit integration; overlooks temporal synchronization and legal issues.
[36]	2018	Explores accessibility and sustainability; limited coverage of digital infrastructure and governance.
[37]	2012	Focuses on urban passenger mobility; lacks infrastructure and legal assessment.
[38]	2016	Examines rail and road coordination; overlooks administrative and legal frameworks.
[39]	2022	Covers accessibility and sustainability; limited discussion on legal and governance aspects.
[40]	2014	Highlights equity and multimodal systems; overlooks legislation and digital systems.
[41]	2009	Analyzes informal and public transport synchronization; lacks governance and legal insight.
[42]	2015	Addresses accessibility and inclusivity; minimal discussion on sustainability and governance.

[35]	2021	Focuses on informal transport systems; lacks integration with formal modes and governance issues.
[43]	2018	Examines road transit systems and accessibility; limited sustainability and digital focus.
[44]	2019	Assesses synchronization and accessibility; neglects environmental and digital policy dimensions.
[45]	2015	Covers passenger transport and infrastructure; overlooks formal governance and environmental aspects.
[46]	2018	Focuses on sustainable mobility and inclusivity; limited legal and administrative integration.
[47]	2023	Explores multimodal transport and accessibility; lacks sustainability and governance focus.
[48]	2018	Discusses infrastructure and accessibility; minimal environmental and synchronization discussion.
[49]	2022	Highlights sustainability and accessibility; limited legal and governance scope.
[30]	2014	Examines public transport efficiency; lacks a formal assessment of legal and digital frameworks.
[37]	2012	Covers passenger satisfaction and performance; limited governance and sustainability scope.
[44]	2019	Focuses on transport infrastructure and equity; minimal governance and legal insight.
[50]	2010	Addresses infrastructure and social sustainability; overlooks digital and legal considerations.
[51]	2017	Analyzes multimodal coordination; lacks sustainability and governance perspectives.
[52]	2022	Focuses on passenger systems and infrastructure; limited environmental assessment.
[53]	2020	Examines accessibility and public transit design; omits governance and legal frameworks.
[54]	2020	Explores sustainability and infrastructure; lacks digital and governance integration.
[39]	2022	Focuses on rail and road sustainability; limited administrative discussion.
[38]	2016	Addresses multimodal integration; overlooks legal and digital systems.
[55]	2021	Discusses accessibility in public transport; lacks sustainability and governance focus.
[56]	2016	Explores multimodal transport; overlooks legal and synchronization issues.
[57]	2023	Focuses on sustainability; lacks coverage of governance and inclusivity aspects.
[58]	2020	Analyzes accessibility and governance; overlooks sustainability and digital policy areas.
[59]	2022	Highlights infrastructure development; limited focus on environmental sustainability.
[60]	2022	Examines transport efficiency; neglects governance and sustainability integration.
[61]	2018	Addresses infrastructure and roads; overlooks legal and environmental policy aspects.

Results and Discussions:

The systematic review of studies revealed a clear thematic divergence in how formal and informal transit systems are assessed. The findings are structured below to highlight these distinct assessment paradigms and the nascent efforts toward integration.

The Formal Transit Assessment Paradigm: Standardization and Quantitative Metrics:

The assessment of formal public transport is dominated by a paradigm of standardization and quantitative performance measurement. The analysis shows a strong reliance on established metrics such as **Level of Service (LOS)**, operational efficiency (e.g., on-time performance, vehicle occupancy), and economic viability [17]. Methodologically, multi-criteria decision-making (MCDM) techniques, particularly the **Analytical Hierarchy Process (AHP)**, are frequently employed to weigh and aggregate these indicators, focusing on objectives like congestion reduction and ridership maximization.

A key finding is that formal transit assessments are often technocratic, prioritizing factors that are easily quantifiable. While this allows for benchmarking and systematic improvement, it often sidelines more nuanced socio-economic dimensions, such as equity of access for the most marginalized communities, which may not be fully captured by standard accessibility metrics.

The Informal Transit Assessment Paradigm: Navigating Unregulated Complexity:

In stark contrast, the literature on informal transit assessment grapples with its inherent unregulation. The results indicate that research in this domain focuses less on standardized performance and more on understanding user perception, driver welfare, and operational logic [18][19]. Studies emphasize the need for context-specific service quality measures that are distinct from those used for buses, often highlighting the critical importance of operator earnings and quality of life as key sustainability indicators.

This review identifies a significant methodological gap: the lack of formal benchmarks and consistent data collection methods for informal transit. Consequently, assessments are often qualitative, small-scale, or reliant on observational data. This evidence gap directly contributes to policy inertia, as regulators lack the robust, comparable data needed to effectively engage with and integrate these services.

The Integration Gap: Conflicting Paradigms and Missing Holistic Frameworks:

A central finding of this review is the pronounced disconnect between the two assessment paradigms described above. While numerous studies discuss the *concept* of integration [62], the results show a near-total absence of operational assessment frameworks designed to evaluate the *combined performance* of formal and informal systems.

The analysis reveals that proposed methodologies for integration, such as land-use-transport models [63] or multi-criteria evaluations [25], remain largely theoretical or focused on high-level planning. They fail to reconcile the quantitative, efficiency-focused approach of formal assessment with the qualitative, livelihood-focused approach of informal transit evaluation. **This is the core integration gap:** no framework successfully merges the technocratic metrics of formal transit with the socio-economic realities of informal transit into a unified set of indicators that can guide integrated policy and planning.

Table 3. Comparative Analysis of Assessment Paradigms

Assessment Dimension	Formal Transit	Informal Transit
Primary Focus	Operational Efficiency, Economic Viability	User Perception, Driver Livelihoods, Adaptability
Core Methodology	Quantitative, Standardized (LOS, AHP)	Qualitative, Case-Study, Observational
Governance Lens	Regulatory Compliance, Subsidy Allocation	Understanding Informal Regulations, Policy Prescriptions
Key Strength	Enables Benchmarking & Systematic Investment	Captures Ground-Level Realities & Social Role
Critical Limitation	Often Overlooks Equity &	Lacks Standardization, Impeding

	Contextual Nuance	Scalable Policy

This comparative insight directly addresses the research objective and underscores the fundamental challenge in achieving sustainable urban mobility: without integrated assessment tools, planning will continue to treat formal and informal systems in isolation, perpetuating inefficiencies and equity gaps.

Conclusions and Looking Ahead:

Key dimensions of this assessment include socio-economic equity, environmental sustainability, effective governance and planning, and the transformative potential of technology and data. The overarching conclusion is that sustainable urban mobility in developing cities requires comprehensive, context-specific, and adaptive frameworks that embrace the complexities and interdependencies of formal and informal transport systems, moving towards more inclusive, efficient, and environmentally sound solutions.

A systematic literature review on assessment frameworks for formal and informal transportation reveals a rich body of knowledge, yet also highlights areas requiring further investigation. While distinct methodologies exist for evaluating formal and informal modes individually, there is a growing recognition of the need for integrated assessment frameworks. Such frameworks are crucial for understanding the synergistic effects of different transport modes, optimizing urban mobility, and informing policy decisions that promote efficient, equitable, and sustainable transportation systems. Future research could focus on developing more comprehensive and adaptable integrated assessment models that account for the unique characteristics and evolving dynamics of both formal and informal transportation in diverse urban contexts.

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