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# OPERATIONAL SUSTAINABILITY OF LAST-MILE PARATRANSIT UNDER MODERNIZATION FRAMEWORKS: A PRISMA-COMPLIANT SYSTEMATIC REVIEW OF TRICYCLE GOVERNANCE AND LIVELIHOODS

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## ABSTRACT

**Background**: The execution of large-scale transport reforms, such as the National Public Utility Vehicle Modernization Program (PUVMP) and the ₱74.3 billion Asian Development Bank-backed Davao Public Transport Modernization Program (DPTMP), introduces structural disruptions for grassroots last-mile transport operators. While infrastructure benefits are thoroughly documented, the organizational and economic survival of Tricycle Operators and Drivers Associations (TODAs) remains critically under-examined.

**Objectives:** This systematic review synthesizes global, national, and localized empirical literature to evaluate the operational sustainability of community-based paratransit systems specifically Philippine TODAs across four core vectors: economic viability, operational adaptability, regulatory compliance, and service continuity under state-led transport transitions.

**Methods**: Following PRISMA guidelines, 145 records were identified through searches of Google Scholar, Scopus, JSTOR, and TRID. After title and abstract screening, 68 studies were retained for eligibility assessment, resulting in 21 studies that met the inclusion criteria and were subjected to thematic narrative synthesis.

**Results:** The synthesized data demonstrates that top-down public transit modernization programs consistently execute a shift from "competition in the market" to "competition for the market," fundamentally threatening fragmented, low-capital paratransit operations. In the Philippines, the traditional boundary system restricts driver revenues (PHP 500 to PHP 800 daily) against fixed daily lease costs (PHP 800 to PHP 1,100), minimizing their capability to absorb capital-intensive modern assets (>PHP 950,000). Furthermore, multi-layered regulatory friction between centralized franchising authorities (LTFRB) and localized government units (LGUs) exacerbates service continuity risks and operational boundary layout challenges.

**Conclusion**: Long-term paratransit sustainability is highly contingent upon moving away from top-down, exclusionary mandates and transitioning toward integrated meta-governance networks that formalize TODA roles as structurally protected, protected feeder nodes to trunk-and-feeder transport frameworks.

**Keywords:**
Last-Mile Transportation, Paratransit Sustainability, Public Transport Modernization, TODA Governance, PRISMA Review, Transport Equity.

## INTRODUCTION

Urban transit architecture within the Global South relies deeply on paratransit networks to deliver necessary passenger mobility. In the Philippines, this landscape is characterized by Tricycle Operators and Drivers Associations (TODAs), which serve as primary last-mile transport networks that bridge critical gaps left unaddressed by capital-heavy, formal transit systems. These associations function as localized socio-technical units that navigate narrow street layouts, provide high-frequency operations, and establish trunk-line connections across marginalized communities.

Despite their systemic importance, paratransit networks are facing significant operational strains due to the implementation of state-led modernization programs. In the domestic sphere, the Department of Transportation (DOTr) initialized this transition via Department Order 2017-011, establishing the Public Utility Vehicle Modernization Program (PUVMP). This framework mandates the absolute phase-out of transport fleets exceeding 15 years of operational service, forcing a transition toward Euro-4, Euro-5, electric, or hybrid

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propulsion units equipped with Global Positioning Systems (GPS), Automated Fare Collection Systems (AFCS), and onboard monitoring systems.

At the regional scale, this national directive is heavily localized through the 2025 Davao Public Transport Modernization Program (DPTMP). Backed by a ₱74.3 billion ($1 billion USD) loan infrastructure investment from the Asian Development Bank (ADB), the DPTMP establishes a massive 672-kilometer high-capacity bus system across Metro Davao. The system leverages 1,100 clean-diesel and electric articulated buses deployed across complex network tiers: 9 feeder loops, 8 inner urban lanes, and multi-linked rural routes running straight through historic tricycle operational layouts.

This massive restructuring exposes a profound structural friction. While the economic, macro-environmental, and technological efficiencies of trunk line bus deployment are heavily validated, the literature exhibits an empirical blind spot regarding how these high-capacity corridors impact the underlying paratransit systems. Paratransit operators function with low financial reserves and informal organizational structures, leaving them highly vulnerable to top-down policy changes.

Despite the growing body of literature on public transport modernization, most studies focus on infrastructure efficiency, environmental performance, fleet modernization, and commuter outcomes. Comparatively little attention has been given to the long-term operational sustainability of community-based paratransit organizations, particularly Tricycle Operators and Drivers Associations (TODAs), which remain critical providers of first- and last-mile mobility in many Philippine cities.

Existing research often examines modernization programs from either a technological or policy perspective, while overlooking how governance reforms reshape the livelihoods, regulatory status, and operational resilience of grassroots transport operators. Furthermore, no known systematic review has synthesized the emerging evidence on TODA sustainability within the context of large-scale transport modernization initiatives such as the Public Utility Vehicle Modernization Program (PUVMP) and the Davao Public Transport Modernization Program (DPTMP).

This review addresses this gap by providing a PRISMA-guided synthesis of the literature on tricycle governance, livelihood sustainability, regulatory adaptation, and service continuity. By integrating Systems Theory, Sustainability Theory, and Governance Theory, the study offers a multidimensional understanding of how modernization policies influence the long-term viability of last-mile transport systems.

A recurring point of agreement across the literature is that modernization initiatives can improve environmental performance, service reliability, and passenger comfort. Studies by Agaton et al. (2020), Ardila-Gomez and Darido (2024), and Lamiri and Supriyanto (2023) collectively suggest that modernization contributes to cleaner transport systems and more structured service delivery.

However, substantial disagreement exists regarding the distribution of modernization benefits. While policy-oriented studies emphasize efficiency gains and emissions reduction, governance-focused research argues that reforms often impose disproportionate costs on informal and low-capital transport operators. Several studies contend that modernization succeeds only when incumbent operators are integrated into the transition process, whereas others assume that market consolidation alone will produce sustainable outcomes. These contrasting perspectives underscore the need for a more balanced understanding of modernization that considers both transport efficiency and livelihood sustainability.

## OBJECTIVES

This systematic review reformulates existing empirical literature into a PRISMA-compliant synthesis to resolve a core question: How do large-scale public transport modernization programs alter the operational sustainability, regulatory status, and service continuity of last-mile paratransit networks within developing urban landscapes?

## METHODOLOGY

### Eligibility Criteria

To ensure high thematic focus and empirical validity, studies were evaluated against strict inclusion and exclusion criteria:

- **Inclusion Tiers:** (1) Peer-reviewed academic papers, public policy reports, and institutional studies published between 2007 and 2026; (2) Investigations focusing directly on paratransit systems, last-mile mobility, tricycle/TODA structures, or informal transport economics; (3) Analyses evaluating public transport modernization, fleet consolidation, or multi-level transport governance transitions within the Global South, with primary emphasis on the Philippines.

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- **Exclusion Tiers:** Studies evaluating macro-level rail infrastructure, heavy maritime transport, private vehicular logistics, or pure consumer-side satisfaction metrics independent of provider operational sustainability.

**Information Sources & Search Strategy**

Systematic literature identification was deployed across four primary academic engines: Google Scholar, Scopus, JSTOR, and the Transportation Research International Documentation (TRID) database. The specialized search strings integrated Boolean logic operators to isolate critical target segments:

- ("public transport modernization" OR "PUVMP" OR "DPTMP") AND ("paratransit" OR "tricycle" OR "TODA")
- ("last-mile connectivity" OR "informal transport") AND ("operational sustainability" OR "regulatory compliance")
- ("transport governance" OR "franchise consolidation") AND ("livelihood displacement" OR "urban mobility")

**Study Selection & Data Extraction**

The extraction workflow followed a strict multi-tier screening process: initial identification yielded 145 records, title and abstract screening retained 68 records, full-text quality assessment evaluated 32 documents, and ultimately 21 core empirical papers and policy documents were selected for full structured synthesis.

| STAGE | RECORDS |
|---|---|
| **Identification** | |
| *Records identified through databases* | 145 |
| **Screening** | |
| *Records screened by title and abstract* | 145 |
| *Records excluded* | 77 |
| **Eligibility** | |
| *Full-text articles assessed* | 68 |
| *Full-text articles excluded* | 36 |
| **Included** | |
| *Studies included in synthesis* | 21 |

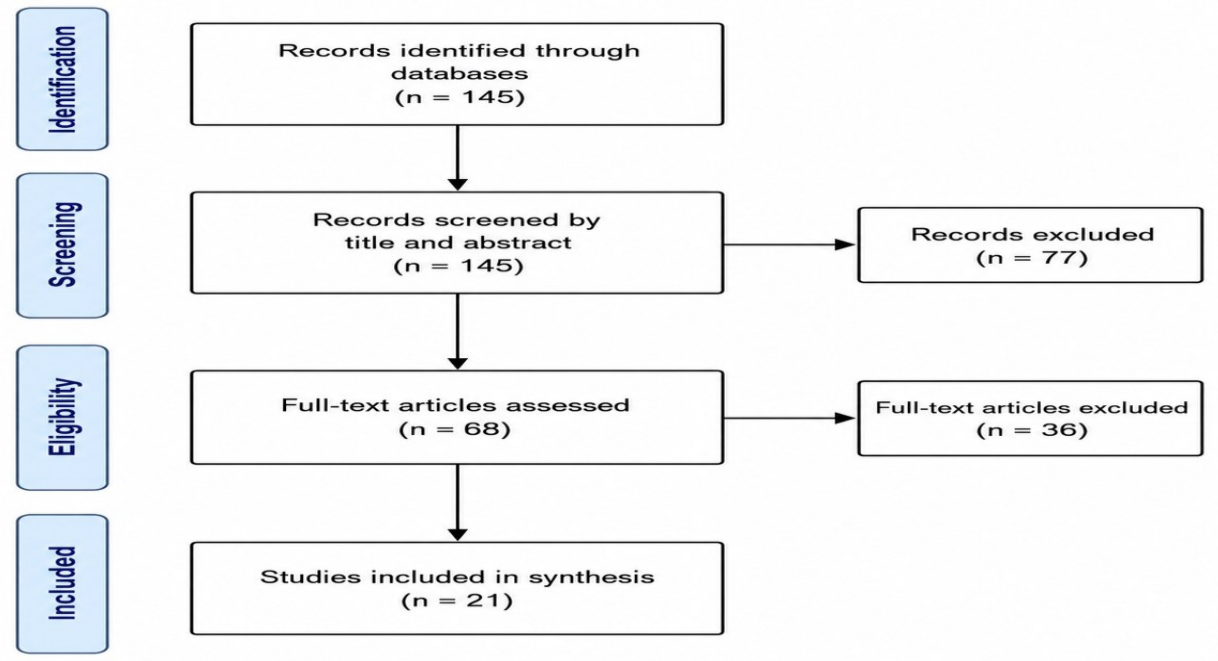


*Figure 1. PRISMA Flow Diagram of Study Selection Process*

**Quality Assessment of Included Studies**

To ensure the reliability of the synthesized evidence, all full-text studies underwent a structured quality assessment prior to inclusion. Studies were evaluated using four criteria: (1) relevance to paratransit

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sustainability and transport modernization, (2) methodological rigor, (3) clarity of findings, and (4) policy relevance. Each study was independently assessed by the primary researcher using these criteria and subsequently reviewed by the research adviser to ensure consistency in classification. Based on the overall assessment, studies were categorized as high, moderate, or limited evidentiary value. Of the 21 included studies, 12 were classified as high quality, 7 as moderate qualities, and 2 as limited qualities. Studies categorized as limited quality were retained only when they provided unique policy or contextual evidence unavailable from higher-quality sources. Priority was given to peer-reviewed journal articles, institutional reports, and policy analyses with clearly documented methodologies. Sources lacking sufficient methodological detail or direct relevance to the research objectives were excluded during the full-text screening stage. This quality assessment process enhanced the credibility of the final evidence base and reduced the inclusion of weak or speculative findings.

**Data Extraction and Evidence Synthesis**

A structured data extraction matrix was developed to ensure consistency across studies. Information extracted included publication details, geographical context, transport system focus, research design, governance dimensions, sustainability indicators, and major findings.

Following extraction, a thematic narrative synthesis approach was employed. Studies were coded according to recurring concepts related to economic viability, operational adaptability, regulatory compliance, and service continuity. Themes were iteratively refined through comparative analysis, allowing common patterns, contradictions, and contextual differences to emerge across the literature. The resulting thematic categories formed the basis of the analytical matrices presented in the Results section.

## RESULTS

The systematic screening process yielded 21 core empirical papers and policy documents that establish the foundation for this analysis. The extracted data is organized into three analytical matrices tracking the structural dimensions of the last-mile dilemma.

***Table 1: Global and Regional Modernization Dynamics & Structural Models***

| Study & Year | Regional Locus | System Focus | Analytical Method | Structural Findings & Core Outcomes |
|---|---|---|---|---|
| Agaton et al. (2020) | Philippines (National) | Public Utility Vehicles / PUVMP | Socio-economic & techno-environmental analysis | Identifies modernization as an inevitable pathway for emissions reduction, but highlights severe structural inequalities in clean asset acquisition. |
| Lamiri & Supriyanto (2023) | Indonesia | Public Transit Network | Qualitative policy analysis | Highlights that while modernization increases passenger comfort, external government mandates frequently override local paratransit adaptabilities. |
| Ardila-Gomez & Darido (2024) | Latin America | Paratransit & Bus Rapid Transit | Comparative case analysis | Identifies a structural shift from "competition in the market" to |

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| | | | | "competition for the market." Emphasizes that excluding operators causes systemic reform failure. |
| Yu (2024) | Davao City, Philippines | High-Capacity Bus Grid / DPTMP | Project monitoring & civil works tracking | Documents the deployment of a 672-km network funded by a $1B USD ADB loan, creating major route conflicts with pre-existing tricycle zones. |

*Table 2: Economic Dimensions & Driver Livelihood Vulnerabilities*

| Study & Year | Regional Locus | System Focus | Analytical Method | Structural Findings & Core Outcomes |
|---|---|---|---|---|
| Velasco (2024) | Philippines | Jeepney/Tricycle Cooperatives | Just transition framework analysis | Quantifies the boundary system: operator leases run PHP 800–1,100/day against driver incomes of PHP 500–800, providing zero buffer for modernization costs (>PHP 950K). |
| Velez (2024) | Provincial Philippines | Fleet Transit Management | Quantitative descriptive operations assessment | Exposes an operational disconnect: management satisfaction remains high while frontline drivers and riders suffer from unmaintained assets and poor scheduling. |
| Fillone & Mateo-Babiano (2018) | Metro Manila | Non-Motorized Pedicabs / Tricycles | Logit choice modeling & intercept surveys | Confirms paratransit dominance for short-haul trips (~1 km); demand is driven by high access/egress times on formal transit |

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| | | | | lines. |
| Mesquita et al. (2026) | Global Urban Centers | Last-Mile Transport Channels | Systematic literature synthesis | Establishes that the final leg of travel holds disproportionate financial weight, absorbing up to 53% of total transport network operational costs. |

*Table 3: Regulatory, Institutional, & Multi-Level Governance Constraints*

| Study & Year | Regional Locus | System Focus | Analytical Method | Structural Findings & Core Outcomes |
|---|---|---|---|---|
| Elipe et al. (2024) | Occidental Mindoro, Philippines | Localized TODA Networks | Descriptive-correlational analysis | Proves baseline rule compliance is high among organized TODA members, but reveals an inverse relationship: compliance drops as operational seniority increases. |
| Sunio et al. (2025) | Metro Davao, Philippines | Regional Transport Franchising | Institutional policy evaluation | Identifies centralization challenges: LTFRB's centralized control over franchises conflicts with localized LGU spatial planning, creating major regulatory gridlocks. |
| Angeles et al. (2024) | Philippines | Land Transport Bureaucracy | Public administration review | Critiques top-down reforms for lacking legislative integration, regular agency budgets, and local technical capacities, which degrades service quality. |
| Respicio & Co. (2025) | Philippines | TODA Legal Frameworks | Jurisdictional & corporate law | Clarifies that TODA authority is |

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| | critique | strictly private and non-stock; attempting to alter LGU franchises constitutes ultra vires actions vulnerable to legal challenges. |

**Emergence of Themes**

The thematic analysis revealed four interconnected sustainability dimensions: economic viability, operational adaptability, regulatory compliance, and service continuity. These dimensions did not emerge independently but rather formed a mutually reinforcing system. Financial vulnerability limited operators' ability to comply with modernization requirements, while regulatory uncertainty constrained operational adaptation. Together, these factors influenced the long-term continuity of last-mile transport services. The literature consistently demonstrated that sustainability outcomes depended on the interaction of all four dimensions rather than on any single factor.

## RESULTS AND DISCUSSION

**Theoretical Syntheses of Modernization Disruptions**

**Systems Theory:** Systems Theory frames TODAs as highly responsive, open organizational subsystems operating within a shifting urban transport ecosystem. When the state implements a massive environmental shock like the ₱74.3 billion DPTMP bus network, it reshapes the external environment of these subsystems. Because these networks are highly interconnected, changes in trunkline bus routing disrupt the internal inputs of the TODA system, causing sharp drops in passenger volume and driving down daily revenues.

**Sustainability Theory:** Sustainability Theory challenges purely financial survival metrics by applying the Triple Bottom Line framework, which requires the simultaneous balance of economic, social, and institutional factors. The synthesized data proves that TODA sustainability cannot be measured solely by net revenue. Instead, it depends on an association's institutional resilience its capacity to adapt routing frameworks, maintain regulatory compliance under new vehicle mandates, and preserve social relevance as a primary short-haul provider for underserved communities.

**Governance Theory:** Governance Theory provides an analytical lens to critique the shift from top-down government mandates to collaborative, network-driven public management. The data highlights a distinct structural gap: transport transitions frequently stumble because they rely on top-down directives that lack vertical and horizontal coordination. When the LTFRB retains centralized franchising power while local LGUs handle actual traffic and route management, it creates an institutional gridlock. This lack of coordination limits the adaptive capacity of small-scale transport operators, leaving them stranded in a complex regulatory landscape without clear institutional guidance.

**The Last-Mile Dilemma: Structural Disconnects**

The systematic review exposes a core structural mismatch in public transport modernization. Governments rely on a "competition for the market" model, which uses long-term, high-capital performance contracts to manage large bus networks. While this approach successfully cuts emissions and optimizes trunk line efficiency, it often harms the informal "competition in the market" model that keeps paratransit alive. The data demonstrates that forcing low-capital tricycle operators to adopt expensive green assets without robust financial support mechanisms creates a high barrier to entry. This often leads to worker displacement and expands the market for illegal, unregistered ("colorum") transport units.

Furthermore, transit planning often overlooks the physical layout of last-mile environments. High-capacity bus lines are efficient along wide highways, but they cannot navigate the narrow, high-density streets where tricycles operate. By forcing transfers without integrating paratransit networks into the broader system, modernizations can reduce low-income commuter access. This underlines a key insight from the review: paratransit systems are not obsolete roadblocks to modernization; they are essential feeder components that require formal integration and structural protection.

**Comparative Perspectives from International Modernization Programs**

The findings of this review are consistent with modernization experiences observed in Indonesia and several Latin American cities. In Indonesia, modernization initiatives improved service quality but frequently reduced the operational flexibility of local transport providers. Similarly, Bus Rapid Transit reforms in Latin America

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demonstrated that excluding incumbent operators often generated resistance, service disruption, and implementation challenges. These international experiences suggest that modernization outcomes are most sustainable when governments pursue inclusive governance arrangements that integrate existing operators into formal transport networks rather than replacing them outright. The Philippine experience therefore reflects a broader pattern observed across developing urban transport systems.

## CONCLUSION

This systematic review demonstrates that the long-term operational sustainability of last-mile paratransit under programs like the 2025 Davao Public Transport Modernization Program depends on moving away from exclusionary, top-down mandates. While clean transit investments improve environmental indicators, they often strain the economic viability of small-scale transport operators. The financial pressures of the traditional boundary system, combined with fragmented regulatory oversight between national and local authorities, limit the ability of grassroots associations to adapt to modern transport standards. Ultimately, paratransit networks are vital components of urban mobility. Ensuring their survival requires moving away from pure market competition and transitioning toward collaborative governance frameworks that protect and formalize their role as short-haul feeder lines to modern transit systems.

### Proposed Structural Intervention Framework

The proposed intervention framework is grounded in recurring findings across the reviewed literature. Evidence consistently indicates that fragmented governance structures, limited access to modernization financing, and weak integration of paratransit services into formal transit planning represent the primary barriers to sustainable transition. Consequently, the recommendations focus on institutional coordination, participatory governance, and financial inclusion mechanisms that directly address these documented constraints.

**1. Macro-Level Policy Integration (Institutional Tier):**

Establish formalized, multi-agency transport planning groups that bridge national directives (DOTr, LTFRB) with localized implementation offices (LGU, TTMO). Mandate the inclusion of Local Public Transport Route Plans (LPTRPs) that explicitly map and legally protect tricycle networks as exclusive feeding systems for high-capacity bus corridors, preventing route overlap and market cannibalization.

**2. Meso-Level Governance and Co-Mapping (Operational Tier):**

Transition from strict top-down regulatory enforcement to collaborative network governance. Engage TODA leadership directly in joint route co-mapping initiatives. Use data-driven spatial tracking to establish official transfer hubs, matching bus frequencies with local paratransit schedules to reduce commuter waiting times and protect paratransit passenger volume.

**3. Micro-Level Economic Subsidization (Financial Tier):**

Restructure the capital acquisition model for fleet modernization. Replace the extractive boundary lease system with cooperative asset management models. Provide low-interest government equity grants and customized banking programs to bypass bureaucratic hurdles, allowing consolidated TODA cooperatives to acquire energy-efficient electric tricycles without taking on predatory debt loads.

### Limitations and Future Research Directions

This review is subject to several limitations. First, the DPTMP remains in an evolving implementation stage, limiting the availability of long-term post-implementation evidence. Second, much of the available literature originates from major metropolitan areas, creating potential geographical bias and limiting the generalizability of findings to smaller cities and municipalities. Third, publication bias may exist because studies reporting successful modernization outcomes are more likely to be published than studies documenting implementation failures or negative livelihood impacts. Finally, variations in research design, methodological approaches, and measurement indicators across the included studies constrained direct comparison of outcomes.

Future research should prioritize longitudinal assessments of TODA revenues, route adaptation behavior, and institutional resilience following modernization implementation. Mixed-methods investigations combining GPS-based route analysis, economic impact assessment, and governance evaluation would provide stronger empirical evidence regarding the long-term sustainability of last-mile transport systems.

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