



Prism

Partnership for Research on
Informal and Shared Mobility

LIVING LABS Working Paper Series

From Diagnosis to Action: A Theory of Change Framework for Informal and Shared Mobility in Bogotá

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PRISM Working Papers Series- An Introductory Note

The Partnership for Research on Informal and Shared Mobility (PRISM) is a global consortium that focuses on better understanding informal transport and shared mobility (ISM) with a focus on Asia, Africa, and Latin America. Centered on the "3 Es"-equity, ecosystems and engagement-PRISM relies on the methodology of urban living labs, located in eight cities (Accra, Bangkok, Beijing, Bogotá, Cape Town, Kumasi, Mumbai, and San José) to co-create knowledge and solutions for the inter-related challenges around ISM like like access, affordability, safety, emissions reduction, inclusion, integration, labor conditions and public health.

This first PRISM Working Papers series pursues two main objectives. First, it aims to provide a platform for living labs to share the research stemming from their specific contexts and highlighting specific research gaps. Second, it intends to stimulate discussion among the living labs and other researchers across a wide range of academic disciplines to foster future comparative research.

The papers in this series vary in their level of technicality and specialization. Therefore, this series aims as much to wide and interdisciplinary audiences as to technical and specialist ones. The papers have been reviewed by at least one member of another living lab before publication. The content of these working papers can be cited as follows: Last name author(s), First name author(s) (Year). *Title of paper*. Partnership for Research on Informal and Shared Mobility (PRISM), New York (USA).

As an example: Oviedo, D., Sánchez-Gómez, J.E., Guevara-Aladino, P., & Guzmán, L.A. (2025). *From Diagnosis to Action: A Theory of Change Framework for Informal and Shared Mobility in Bogotá*. Partnership for Research on Informal and Shared Mobility (PRISM), New York (USA).

Abstract

A diverse array of informal and shared transport services, including shared taxis, minibuses, motorcycle taxis, and bicycle taxis, shape part of Bogotá's mobility landscape. These systems provide flexible mobility options for underserved communities, yet they operate with varying degrees of governance, regulation, and embeddedness within their local contexts. While some modes have established semiformal structures, others remain in regulatory limbo, facing challenges such as limited recognition in transport planning, road safety concerns, conflicts with formal public transport systems, and vulnerability to policy shifts. This paper presents the Bogotá Informal and Shared Mobility Living Lab, a participatory urban living lab designed to engage transport operators, communities, and policymakers in co-producing experimental solutions to improve mobility futures. Using a Theory of Change approach, the Lab has developed a structured framework for fostering collaborative problem-solving and adaptive policymaking. Through an iterative process of participatory diagnosis, thematic dialogues, and co-creation of intervention pathways, the Lab defined the mission, vision, and structure of local teams, which will facilitate future experimentation and localised action in several locations where shared mobility systems, such as collective-use vans, informal shared taxis, and bike-taxis, operate under distinct regulatory and community conditions. By placing participatory research, governance adaptation, and knowledge co-production at its core, the Lab approach provides a scalable and adaptable model for engaging with informal transport providers and communities in rapidly urbanising cities. The findings demonstrate how these instruments can serve as structured platforms for testing alternative mobility governance models, fostering intersectoral collaboration, and integrating informal mobility into broader urban sustainability frameworks. This paper outlines the methodology underpinning the Lab and highlights its potential to inform policy innovation, experimental mobility solutions, and inclusive governance for shared transport systems in Bogotá and beyond.

Keywords: urban living lab; participatory planning; informal transport; transport justice; Bogotá.

1. Introduction

Urban expansion across the Global South, particularly in Latin America, presents profound challenges for inclusive mobility. Rapid population growth coupled with market-driven real estate development often extends city boundaries far beyond the reach of formal public services, creating patterns of spatial segregation and exclusion (Sierra et al., 2024). As cities sprawl, the demand for accessible transport intensifies. Yet, formal systems frequently struggle to keep pace, leaving many residents, especially those in peripheral, lower-income settlements, disconnected from urban opportunities. This disconnect is exacerbated by the region's deep-seated social vulnerabilities, where limited affordability prevents many from accessing private vehicles or even the fares of formal public transport (Gómez-Lobo, 2025). It is within these gaps—between demand and formal supply—that diverse informal and shared mobility (ISM) systems emerge. These systems, encompassing modes like shared taxis ('colectivos' or 'pirates'), minibuses, motorcycle taxis, and bicycle taxis ('bicitaxis'), often arise organically as community-based responses, providing essential, flexible, frequent, and usually more affordable transport solutions where formal options are lacking or inadequate (Cervero, 2000). This paper presents the Bogotá Informal and Shared Mobility Living Lab, a participatory initiative established as an Urban Living Lab (ULL). Grounded in a Theory of Change (ToC) framework, this paper details the Lab's methodology for collaborative engagement with ISM operators, users, communities, and policymakers to co-produce knowledge and co-design experimental interventions aimed at improving these vital yet complex mobility systems within Bogotá, Colombia.

ISM often functions as a critical feeder system, connecting peripheral neighbourhoods to high-capacity public transport corridors like Bogotá's BRT (TransMilenio), bridging the crucial "first and last mile" gap. Many of these services operate on shared mobility principles, optimising vehicle use along common routes to maintain low fares and operational efficiency, often outside the bounds of formal regulation (Machado et al., 2018). Bogotá's urban landscape vividly illustrates this reality, hosting various ISM services that vary significantly in vehicle type, operational scale, and governance structures. Despite this diversity, the underlying drivers—serving underserved populations and providing essential connectivity—show remarkable consistency, contributing significantly to mobility within the territory (Villar-Uribe, 2021). To capture this heterogeneity, this study focuses on three distinct ISM systems operating in different areas of Bogotá: the collective cars or SUVs (locally known as 'carritos', 'vans' or 'jeeps') navigating the steep, peripheral terrain of a peripheral and low-income district named Ciudad Bolívar; the 'pirate taxis' providing shared rides in the relatively denser, yet

geographically constrained, Pardo Rubio neighbourhood within district of Chapinero (in the mountainous east of the city); and the three-wheeled 'bicitaxis' offering localised services in the expansive southwestern districts of Bosa and Kennedy (see Figure 1). These cases range from largely unregulated operations to semiformal systems, such as bici-taxis, which possess some authorization but lack comprehensive operational regulation.

Despite their importance in the daily lives of millions, these ISM systems grapple with significant, multifaceted challenges that hinder their potential and complicate their relationship with the formal city. Governance remains a primary obstacle; many services exist in a state of regulatory ambiguity, facing inconsistent enforcement, policy shifts, or outright criminalisation, which fosters instability and limits opportunities for improvement or integration (Behrens et al., 2016). This precarious legal status often contributes to issues concerning road safety standards, driver working conditions, fare stability, and service reliability (Golub and Cervero, 2007). Furthermore, integrating ISM with formal public transport systems is often problematic, marked by competition, conflict, or a lack of coordinated planning, which hinders the development of a seamless, multimodal urban mobility network. The profound social and territorial embeddedness of many ISM operations within their communities also presents a governance paradox: while reflecting strong local organisation and responsiveness, this can sometimes translate into resistance to external regulation or difficulty engaging with citywide planning processes. Addressing these intertwined challenges effectively demands approaches that transcend conventional top-down regulation, embracing participatory methods capable of navigating the complex socio-political and operational realities of ISM (Oviedo and Guzman, 2020).

The Bogotá Informal and Shared Mobility Living Lab was conceived as a direct response to this need for innovative, collaborative governance approaches. In this case, the ULL provides a dedicated platform for sustained dialogue and interaction among key actors involved in or affected by ISM, including often-marginalized operators and users, community representatives, academic researchers, and public sector officials. The Lab's core mission is to collaboratively identify the nuanced challenges and latent opportunities within Bogotá's ISM sector through rigorous, participatory data collection and analysis, ultimately empowering stakeholders to explore, design, and potentially pilot context-specific interventions jointly. This initiative explicitly adopts co-creation and place-based experimentation as its core tenets, aiming to develop adaptive, practical solutions informed directly by lived experience and local knowledge.

This paper contributes to the expanding field of Urban Living Labs research, particularly by exploring their adaptation and application within the complex institutional and social landscapes of cities in the Global South, with a focus on the long-neglected informal transport sector. It addresses calls for more context-sensitive, participatory approaches to urban planning challenges, such as transport informality, where standard models often prove inadequate (Machado et al., 2018). By detailing the application of a Theory of Change framework within the ULL structure, the paper also contributes to discussions on innovative transport governance. It showcases a structured methodology for fostering intersectoral collaboration, navigating conflicting interests, and moving from participatory diagnosis towards co-produced action in informal mobility. Ultimately, the Bogotá ISM Living Lab aims to generate transferable insights into how participatory platforms can foster more inclusive, resilient, and equitable urban transport systems, not only in Bogotá but potentially in other cities facing similar challenges.

2. Informal and Shared Mobility in Urban Transport

In rapidly growing cities in the Global South, informal transport can be understood as a privately operated system that typically employs small- to medium-sized vehicles to serve low-income neighborhoods, generally complementing the formal public transport network at an affordable fare (Cervero, 2000). This type of service is also referred to as 'illegal', 'paratransit', 'popular', or 'pirate transport'. The term 'informal' refers to the lack of formal regulation, meaning that its operation is not officially authorized to provide public transport services within the city. In parallel, there are 'semiformal' transport systems which, unlike entirely informal services, hold some degree of legal recognition or authorisation. Nevertheless, these systems operate under informal conditions in aspects such as fare setting, route definition, labor arrangements, insurance, and vehicle ownership (Tun et al., 2020).

In Latin America and the Caribbean (LAC), informal transport services are often self-regulated, organized by local associations that coordinate key operational aspects such as routes, service coverage, operational zones, and fares (Behrens et al., 2016). The principal characteristics of these systems are demand responsiveness, unscheduled and flexible operations, self-organization by private operators, and the absence of government subsidies or formal regulation (Nebrija, 2024). Informal transport operates under three different systems regarding vehicle tenancy: 1) the owner provides the service directly, 2) the owner rents the vehicle to associations to provide the service, and 3) the owner hires a driver to provide the service (Oviedo et al., 2022). Additionally, informal transport includes a variety of vehicles, such as taxis, vans, SUVs, sedans, and two- or three-wheeled vehicles (motorcycles or bicycles).

However, without a central regulatory authority, informal transport in LAC serves not only as urban passenger transport but also as freight transport, household moving, messaging, cargo handling, tourism, and even connects municipalities to nearby population centers. As a result, informal transport spans multiple sectors, making it more challenging for national governments to coordinate the actors involved.

In practice, informal services often exhibit characteristics of shared mobility, which is defined as a system of on-demand private vehicles shared by passengers traveling in the same direction (Santos, 2018). These services typically emerge to serve areas with low public transport coverage, where high-capacity public transport is not feasible (Oviedo et al., 2023). For LAC, shared mobility solutions provide a valuable alternative to the challenges faced by traditional public transport systems.

Several authors have examined the various types of informal transport, including their origins, modes of operation, and implications for modern urban mobility. Multiple studies have shown that these systems often emerge as functional responses to limited availability of transport alternatives (Salon and Gulyani, 2010) and insufficient connectivity to the formal public transport network (Oviedo Hernandez and Dávila, 2016; Talamini and Pires Ferreira, 2019; Vecchio, 2017). These challenges, particularly in LAC, have facilitated the persistence of informal transport services in certain areas, as they contribute to reducing cycles of social exclusion caused by barriers to affordability and accessibility in formal public transport (Nieto-Combariza et al., 2024; Stiller et al., 2025). On the other hand, Golub and Cervero (2007) argue that, despite their adaptability, operators of these systems often face more costs than benefits. These include poor service scheduling, intense market competition, high levels of insecurity, inadequate financial management, tax evasion, labour abuses, irregular business practices, and a limited capacity to meet transport demand. This is relevant to the LAC's broad research agenda, as it highlights the need to enhance well-oriented urban and social development in cities and their inhabitants.

Therefore, studying and understanding this complex phenomenon requires a methodological approach that fosters a comprehensive understanding of the issues involved. The analysis and discussion of urban mobility challenges must include the active participation of ever-growing community-based organisations and non-governmental organisations (Oviedo and Guzman, 2020), as is the case with ISM and the local associations that support it. In turn, the practical design and implementation of transport sector reforms requires collaborative engagement with all relevant stakeholders to achieve genuinely holistic transformation strategies.

Building on the above, a methodological approach that addresses these research needs is the Urban Living Lab (ULL). According to the European Network of Living Labs, a Living Lab (LL) is a research and innovation ecosystem grounded in systematic co-creation through participatory activities with communities, where people are placed at the centre of the innovation process. However, when incorporating an "urban" perspective, the goal is to meet urban sustainability criteria, ensuring that proposed solutions are replicable, sustainable, and responsive to real-life challenges. The key defining characteristics of Living Labs include real-life environments, stakeholder involvement, activities, business models and networks, methods, tools, and approaches, as well as challenges, outcomes, and sustainability (Hossain et al., 2019).

The ULL methodology holds significant potential for application in Latin America. Co-creating solutions with key transport stakeholders —citizens, government, industry, and academia — leads to more sustainable outcomes than processes that rely solely on user feedback (Schneider and Buser, 2018). However, defining the core characteristics of ULLs in the context of ISM presents notable challenges, as the operation, governance, and urban influence of these services are often unregulated or poorly documented. Integrating a ULL to examine ISM dynamics in LAC offers an opportunity to address the specific needs of cities and citizens by focusing on localized problems and context, acting as a platform for development-oriented thinking, while also facilitating negotiation and collaboration among relevant stakeholders (UN-Habitat, 2016). This approach allows ISM to be reframed not merely as a business venture, but as a matter of public concern. To support this process, it is crucial to incorporate complementary qualitative methods, such as focus groups, which enable a more grounded understanding of local realities. These participatory activities contribute to refining the ULL framework by integrating contextualized user insights.

The ULL approach has been applied globally across a wide range of urban challenges. In the LAC context, ULLs have been implemented to address various issues in urban development, including equality in urban health (Alexandrakis, 2021), efficiency in urban logistics (Nesterova and Quak, 2016), and infrastructure resilience in the face of climate change (Amorim et al., 2022). They have also contributed to advancing active mobility within public policy frameworks and climate change agendas (Sagaris and Palacios, 2024), among other applications. However, the implementation of ULLs in the Global South—particularly in LAC—faces significant challenges, including limited financial resources, weak governance structures, and insufficient institutional capacity (Bergvall-Kareborn. et al., 2009; Ondiek and Moturi, 2019). In this context, the effectiveness of ULLs is highly dependent on the local socio-political

environment and the degree to which they are responsive to community concerns, requiring them to address six key challenges: endorsement, relevance, trust, mobilization, inclusion, and long-term sustainability.

3. Context: Overview of Case Studies

This study focuses on Bogotá, Colombia's capital. Bogotá is home to approximately 7.9 million inhabitants, representing around 15% of the national population. In 2023, according to the latest mobility survey, an estimated 12.3 million trips were made daily in the city, of which 0.9% were carried out using informal transport modes. These informal trips are predominantly concentrated in the peripheral zones, where access to public transport is limited, income levels are low, and both population density and travel times are higher.

As shown in Figure 1, the trunk corridors of Bogotá's BRT system, TransMilenio, do not extend to the city's peripheral zones. Consequently, both formal and informal feeder services play a crucial role in connecting these communities to the public transport network. Even though Bogotá fully implemented an integrated public transport system (SITP), these informal services continue to meet part of the demand that the formal system cannot address (Heinrichs et al., 2017).

Based on this context, three case studies were selected, each representing a distinct ISM service located in different areas of Bogotá. The selection of these cases aimed to capture a range of vehicle types, service modalities, operational capacities, and urban contexts. Figure 1 also illustrates the geographical location of these case studies within Bogotá. These include:

1. The collective car service (locally known as 'carritos', 'vans' or 'jeeps') in the Ciudad Bolívar district;
2. The 'pirate taxis' service (or collective taxis) in the Pardo Rubio neighbourhood within the Chapinero district;
3. The three-wheeled 'bicitaxis' service in the southwestern districts of Bosa and Kennedy.

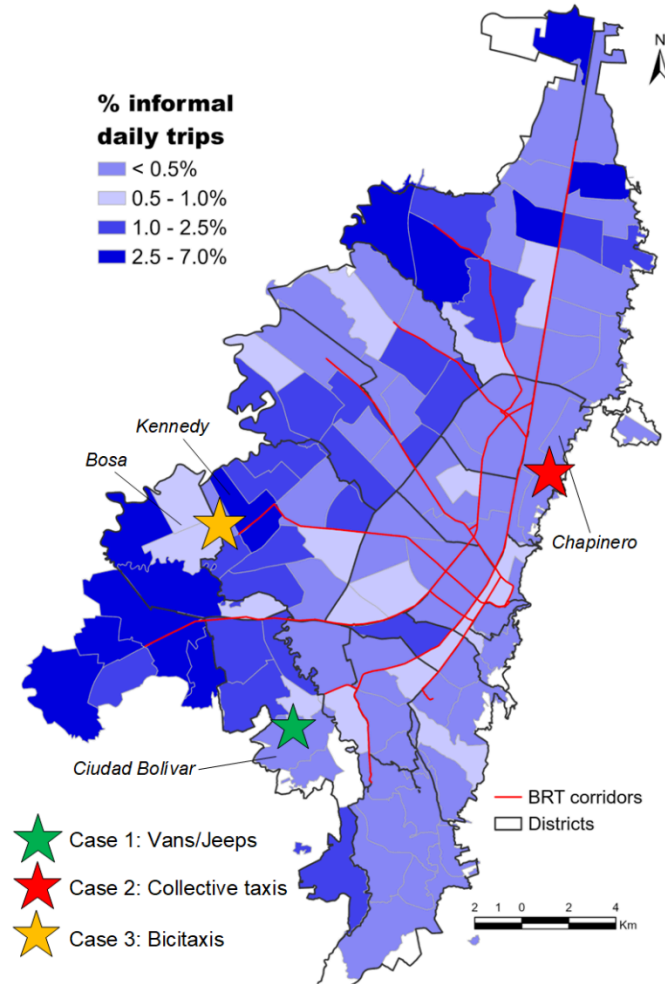


Figure 1. Informal daily trips generated in Bogotá

The first case study focuses on the collective car service (marked with a green star in Figure 1), an informal and shared transport system operating as a collective service in the district of Ciudad Bolívar. This district, located in the southern periphery of Bogotá, is characterised by mountainous terrain, steep slopes, narrow streets, and largely unpaved roads. The service operates near the TransMiCable aerial cable station, which connects residents living in the district's steep and distant hills with the city's BRT system (Guzman et al., 2025). The vehicles are privately owned and operate without formal regulation or authorization to transport passengers. The service is managed by operators known as 'route owners', who autonomously coordinate operational aspects, including service territory, fares, frequencies, and other logistics. Several of these services operate within Ciudad Bolívar, each one confined to its self-designated territory, which defines an exclusive zone of coverage.

The second case study focuses on the pirate taxi service (marked with a red star in Figure 1). This is an informal and shared transport service composed of formal taxis that operate as collective transport vehicles without formal regulation or authorisation. The service operates in the district of Chapinero, specifically serving the neighbourhood of Pardo Rubio, located in the eastern part of the city. Unlike the other two cases, this service is owned by a single individual, who manages the operation with support from 'route leaders'—a group composed of some of the vehicle owners and/or drivers. The neighbourhood's streets are narrow and steep. While the Bogotá's Central Business District (CBD) is located also in Chapinero, which concentrates most of the Bogotá's job market (Guzman et al., 2017), connectivity from Pardo Rubio is challenging due to its peripheral location, rugged topography, and geographic isolation, caused by a major longitudinal road that acts as an urban barrier.

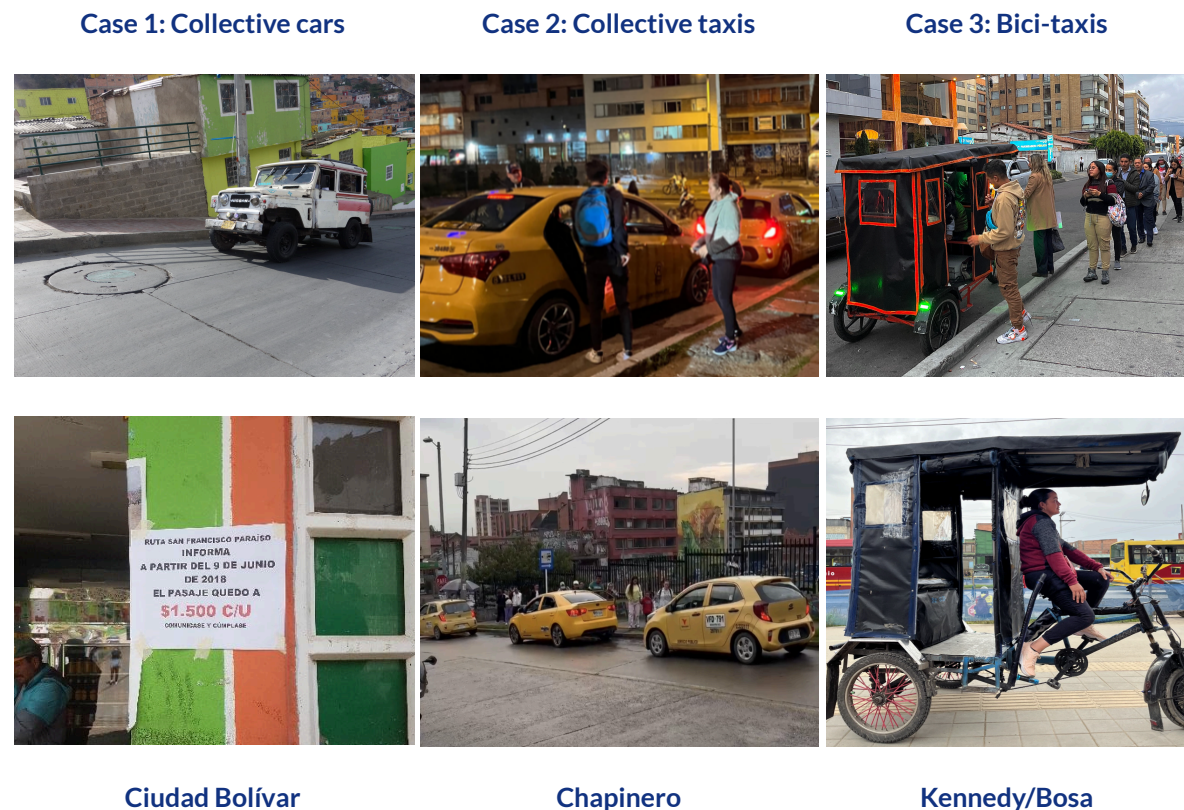


Figure 2. ISM vehicles per case study

The third case study focuses on the bici-taxi service (marked with an orange star in Figure 1). This transport system utilizes three-wheeled bicycles, either manually operated or with motor assistance, equipped with a passenger cabin that accommodates two to three riders. This is a semiformal system, as it is authorised to

operate, yet it functions under informal and unregulated conditions (Tun et al., 2020). Bici-taxi services can be observed throughout the city, particularly near stations of the BRT system. However, for this study, the analysis focuses on the bici-taxi service operating in the districts of Bosa and Kennedy, located in the southwestern periphery of Bogotá. These areas are characterized by limited public transport availability, resulting in lower accessibility and longer travel times compared to other parts of the city (Guzman et al., 2018). Figure 2 shows images of the typical vehicles that operate in each of the areas studied.

4. Proposed methodology

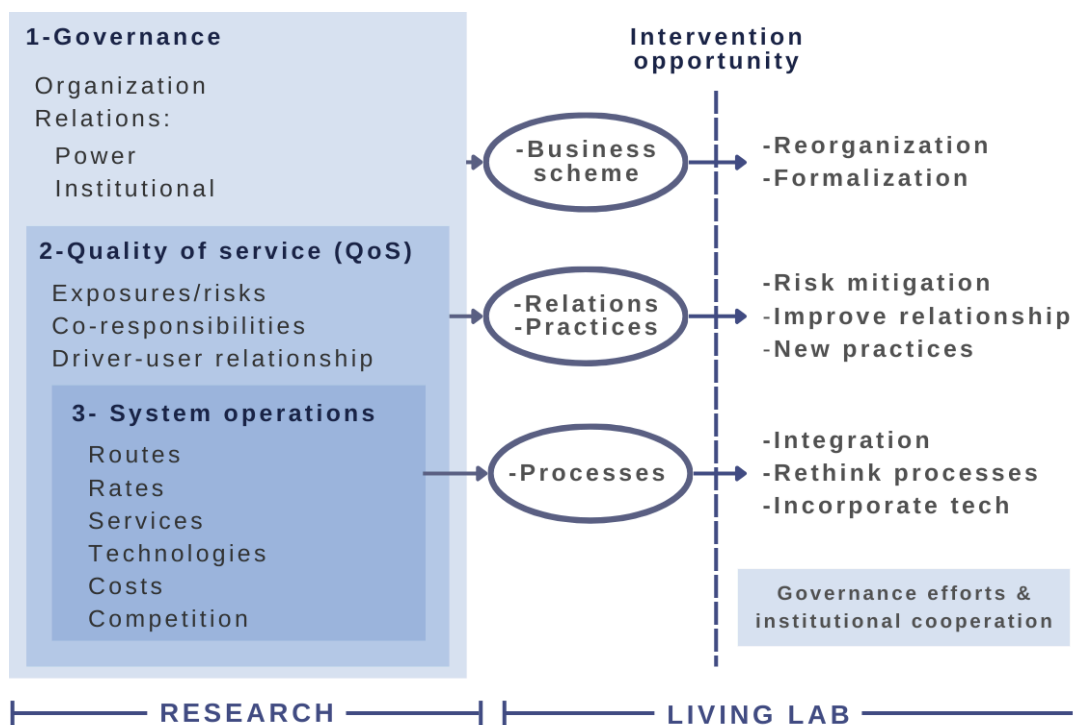


Figure 3. Methodology framework

This study was grounded in establishing a ULL, conceived in response to the need to understand ISM in Bogotá and the LAC region, and to develop strategies for intersectoral collaboration. These strategies aim to involve various stakeholders in co-creating solutions, based on a prior understanding of the operational dynamics, social interactions, and contextual conditions in which these modes of transportation emerge in the city. Figure 3 presents the methodology implemented, which comprises two key components: the participatory diagnosis of ISM in Bogotá (research) and the methodological structuring of the ULL applied to the ISM in the city (Living Lab).

4.1 Participatory Diagnosis and Stakeholder Engagement

In the initial phase of the study, a diagnosis was conducted on the three selected ISM study cases, aimed at describing the system's operation and identifying the key enablers and barriers to its functioning. Six focus groups were held—two in each of the study areas—one with ISM users and the other with drivers and operators. This approach enabled the examination of the ISM's contextual, operational, and social dynamics from the perspectives of various stakeholders.

Social Engagement: A fundamental aspect of the study was the strategic fieldwork conducted within the chosen communities. These communities, particularly those located in the Ciudad Bolívar district, face high levels of vulnerability, low income, and complex socio-political contexts, often involving rights violations, violence, forced displacement, spatial and social marginalisation, and limited access to opportunities. In such contexts, community participation tends to be restricted, necessitating engagement through trusted local leaders or institutions. Hence, our ULL adopted a community-led approach, involving individuals with established legitimacy and familiarity with local dynamics to ensure effective integration.

Once an appropriate fieldwork framework was established, a participatory toolbox was introduced to facilitate social engagement aligned with the study's objectives. Active community participation contributed to both the richness of the data collected and the overall legitimacy of the project (Maund et al., 2022). The field coordinator conducted participant recruitment for focus groups, a well-known figure within the community due to her longstanding involvement in the area. This outreach process spanned two weeks and aimed to engage no more than ten participants per session. Recruitment was carried out through community action boards, local government offices, and ISM operation sites located within the neighbourhoods.

In recognition of the economic challenges faced by participants, a modest compensation was provided for their time, and they were also offered a light lunch. Importantly, this compensation was not disclosed in advance to avoid influencing participation, and the amount was intentionally kept low to minimize incentive-driven involvement. Ethical considerations were rigorously addressed throughout the process, as mandated by the project's ethics committee. All engagement strategies, including recruitment and data collection, were implemented by trained field staff under the direct supervision of the principal investigator. Once participants agreed to take part in the study, informed consent was obtained, ensuring they fully understood the study's purpose, procedures, potential risks, and their right to withdraw at any time without consequence. Additionally, the study

received ethical approval from the institutional ethics committee of the university responsible for its implementation.

Focus Groups: Focus groups are collective participatory spaces designed to explore topics relevant to a given study. They are typically conducted with specific population groups to elicit insights on targeted issues. In this study, focus groups were employed to support the diagnostic phase of the ISM and to guide the methodological structuring of the ULL. A total of six focus groups were conducted, two in each study area (case), distinguishing between service users and drivers or operators. Each session lasted approximately two and a half hours and was held in accessible community-based venues such as auditoriums, local community centers, and library meeting rooms.

The sessions were facilitated by experienced researchers, all of whom possess extensive training in qualitative methods and prior experience conducting focus groups. Additionally, the whole research team was present to support logistical coordination, ensure a contextual understanding, take detailed notes, and engage with participants. This collaborative approach aimed to enhance the quality of the data collected and strengthen the community's connection to one another.

The focus group sessions were conducted within the communities. They explored a range of topics, including perceived service quality, advantages and disadvantages of informal transport, operational conditions, travel purposes, perceived risks, and accessibility. Discussions were guided using semi-structured question sets tailored to each participant group. For drivers, the questions focused on the challenges and opportunities within the informal transport sector, motivations for entering the profession, descriptions of a typical working day, coordination mechanisms among drivers, entry routes into the occupation, organizational structures, use of technology, interactions with law enforcement, and perspectives on potential strategies for formalization. And for users, the questions addressed perceived strengths of informal transport, areas for improvement, cost-related motivations for use, perceptions of safety, personal safety measures taken when using informal transport, and suggestions for enhancing the system to encourage broader or more frequent use.

The two focus groups in Ciudad Bolívar were conducted in April 2024 and included 10 users and 10 drivers/operators. The average age among users was 58, and 55 among drivers and operators. The majority of participants in both groups reported monthly household incomes below two minimum monthly wages (MMW≈295 USD), identified their primary occupation as working, and had attained an elementary or

high school education. In Chapinero, two focus groups were conducted in May 2024, involving nine users and nine drivers/operators. The average age of users was 54, while drivers/operators averaged 42 years old. Among users who responded, most reported household incomes between COP 1 and COP 3 million; the majority of drivers/operators reported earning less than COP 2 million (COP 1 million $\approx$ 256 USD). Participants in both groups primarily identified themselves as working and reported education levels ranging from elementary to high school, as well as technical or technological studies. In June 2024, two focus groups were conducted, with participation from 2 users and 8 drivers/operators, in Kennedy and Bosa. The average age of users was 24, compared to 59 for drivers and operators. Users reported household incomes between 3 and 4 MMW, while most drivers/operators reported less than 3 MMW. Across both groups, most participants were working and had completed either an elementary or high school education. A detailed summary of participant characteristics for each focus group is provided in Table S1 of the Supplementary Section.

Each session also included a social cartography exercise, where users, drivers, and operators marked key points, such as stops, routes, facilitators, barriers, and operational features, on a map related to ISM operation. This process enabled the research team to gain a deeper understanding of the operational dynamics, territorial barriers, and facilitators, as well as the governance structures surrounding informal transport services in Bogotá.

Information Analysis and Synthesis: Following the focus group sessions, a comprehensive analysis of the collected data was conducted using a thematic analysis (TA) and content analysis (CA). TA is a methodology that enables the identification of key themes within qualitative data (Clarke and Braun, 2017). All focus groups were audio-recorded, transcribed verbatim, and thematically analysed using Excel thematic matrices. After conducting the first focus group, three researchers applied TA to identify the emergent themes of the data. After reaching an agreement on categories with the rest of the research team, the transcripts of all focus groups were thematically analysed using the following categories: 1) Governance (4 subcategories), 2) Quality of Service (QoS) (5 subcategories), 3) System Operations (7 subcategories), and 4) Contextual Conditions (3 subcategories). These categories, subcategories, and levels are defined and specified in Table S2 in the Supplementary Section.

Additionally, CA – a methodology aimed at systematically evaluating qualitative content to derive patterns and meanings (Kolbe and Burnett, 1991) – was applied to characterize the information within these thematic categories across the data of the

social cartography outputs resulting from the six focus groups. This process involved reviewing audio recordings, field notes, social cartography outputs, and informal conversations with participants. The data were systematically organized under the four primary analytical categories. Through this combined analysis, the study not only explores the ISM context but also identifies and describes the most frequently mentioned and influential factors affecting ISM operations across the studied cases.

The research is embedded in the governance structure of both the neighbourhoods and popular transport systems under analysis. Fieldwork was also led by experienced facilitators with strong community ties, who implemented a recruitment strategy that built on snowball sampling, prioritizing representation from different levels of community involvement, gender, age, and roles within the transport system (i.e., users vs. operators). While the risk of bias remains, these strategies, coupled with multi-stage mechanisms for the coproduction of evidence, mitigate the possibility of ignoring or obscuring certain voices in the data collection processes.

4.2 Theory of Change as a Framework

To effectively navigate the complexities of ISM in Bogotá and transition from diagnosis to collaborative action, the methodological proposal for the intervention phase of the ULL is grounded in the Theory of Change (ToC) framework. ToC provides a rigorous yet flexible approach for planning, participation, and evaluation within complex social systems, making it particularly well-suited for the dynamic context of urban informality. It operates as more than just a planning tool; it is a process for developing a shared understanding among stakeholders about how change is envisioned and expected to unfold over time (Taplin, 2012).

The core of the ToC methodology involves collectively defining a desired long-term impact, or ultimate end, and then systematically mapping backwards to identify the sequence of outcomes (changes in behaviour, relationships, or conditions) that are necessary preconditions for this impact (Vogel, 2012). This 'backwards mapping' process requires stakeholders to articulate the causal pathways linking inputs (resources), activities (interventions), outputs (the direct results of activities), short-term and medium-term outcomes, and the final long-term impact. This process also involves surfacing and examining the underlying assumptions about why these causal links are expected to hold within the specific project context. By making these pathways and assumptions explicit, ToC facilitates clearer strategic thinking, enhances communication among diverse actors, and creates a robust framework for monitoring progress and adapting strategies based on emergent learning.

The selection of the ToC as the guiding framework for the Bogotá ISM Living Lab was deliberate, driven by its alignment with the research context's challenges and the principles of the ULL approach. Firstly, the complexity, dynamism, and often contested nature of ISM necessitate a methodology that can accommodate non-linear change processes and emergent outcomes, rather than relying on rigid, linear planning models. ToC's flexibility allows for adaptation as understanding evolves through the Lab's activities. Secondly, the framework's inherent emphasis on participation resonates deeply with the ULL philosophy of co-creation. Developing the ToC collaboratively ensures that the perspectives, knowledge, and priorities of ISM operators, users, and local communities are central to defining the Lab's goals and intervention strategies, rather than being imposed externally. This participatory grounding is vital for building ownership, legitimacy, and relevance.

Thirdly, ToC provides a structured way to connect the Lab's specific, place-based experiments and activities to broader goals related to sustainable mobility, governance reform, and social equality. It helps articulate how localised interventions undertaken within the ULL are intended to contribute to systemic change, bridging the gap often seen between pilot projects and broader policy impact. Finally, the explicit nature of a ToC map serves as a powerful tool for communication and accountability. It creates a shared language and visual representation of the Lab's strategy, facilitating dialogue among stakeholders with potentially diverse interests (e.g., community members, transport operators, institutional actors) and providing a transparent basis for evaluating whether the Lab is progressing along its intended change pathways. Building upon the rich insights gained during the participatory diagnosis phase, the ToC framework thus provides the essential structure for the Bogotá ULL to collaboratively define its purpose, design targeted interventions, and navigate the path towards fostering more inclusive and sustainable informal mobility solutions.

5. Findings: Designing a Living Lab for Informal Mobility

This section presents the results in two categories: the diagnosis of the fieldwork with the communities, from which the proposed methodology for building the living lab is derived.

5.1 Diagnosis: Identifying the main issues around each case study

Following the completion of the focus groups, the key aspects perceived by drivers/operators and users were identified concerning the categories of Governance, Quality of Service (QoS), System Operation, and Contextual Conditions.

In this regard, Tables S3 and S4 in the Supplementary Section summarise the elements highlighted by both groups concerning the functioning of the ISM in Bogotá, differentiated according to each case study. Figure 4 shows some images of the workshops conducted with the community in the three case studies.



Figure 4. Users, drivers, and operators focus groups

Based on the results of the focus groups, several perceptions were identified among users of the ISM system in the three case studies. In terms of governance, users expressed an ambiguous perception regarding the organisation of the informal service. Although they recognise the existence of basic hierarchies, such as the role of route owners and drivers, they are largely unaware of the number of routes available or how they are managed internally. While the community has historically participated in dialogue spaces with state institutions to express their expectations regarding the public service, such interactions have diminished over time, reducing opportunities for institutional engagement. In this context, users call for greater coordination among public entities to improve the management and reach of the formal public service, as one user described:

“Back around 2014, there was a citywide consultation in Bogotá, initially starting at the local level. Chapinero, being a very large locality, had its own specific meetings. These meetings were held every two weeks at the Chapinero Town Hall and aimed

to gather community input on their transport preferences. However, despite these consultations, the implementation was not reflective of the community's feedback. The authorities proceeded with their plans, establishing stops, transport routes, and schedules according to their own preferences. They did not consider the input from the people who had been engaged in the consultations, particularly those from the upper areas of the hills".

Regarding the quality of the service, the three cases show significant variation. In Ciudad Bolívar and Kennedy/Bosa, ISM is positively perceived by users, particularly for its high frequency, which translates into shorter travel times, and for its lower fares compared to other modes of transport¹. In contrast, in Chapinero, the relationship between users and service providers is characterised by distrust, reports of mistreatment, and a perceived lack of professionalism among drivers. Across all three case studies, risks are associated with the poor condition of the vehicles, lack of clarity around the legal status of the service, and frequent speeding. In Ciudad Bolívar (collective cars), the service is primarily linked to caregiving tasks and the mobility of community leaders who rely on this mode of transport for their daily activities:

"The danger is that the vehicle could end up without brakes, without a tire. An accident, let's say, could happen at any time because there's no safety at all."

About operations, users demonstrate a high level of familiarity with the routes and designated stops, particularly in Ciudad Bolívar (collective cars) and Chapinero (collective taxis), where ISM operates as a feeder to the formal public transport system. In Kennedy and Bosa (bicitaxis), the service more closely resembles a shared taxi system due to its smaller capacity. Although no technology is currently used to request the service, users see the potential value in a mobile application to improve accessibility. Fares vary depending on the route and time of day, and the service is commonly used for both passenger and cargo transport. One user also mentioned:

"Exactly, due to the user's need, as there is no other transport available. There is no alternative transport; thus, with the urgency of being late for work, what choice do you have? You end up taking it because the bus only arrives in two days."

Regarding contextual conditions, users across the three case studies consistently highlighted the limitations of the formal public transport system. Common issues

¹ The issue of lower fares must be addressed carefully, as it depends on the type of trip the user is making. If the user only uses the informal service, lower fares can be expected. However, if the informal service is used as an additional stage of the journey, which includes the use of formal public transport, the cost of the trip can increase by approximately 56%.

include disorganized urban development, lack of comprehensive planning, and insufficient road infrastructure, often characterized by narrow streets, steep slopes, and unfinished public works. There is little to no contact with city-level authorities, and users perceive a gradual reduction in route availability and frequency, trends that reinforce their reliance on ISM. A user described:

"One of the issues being experienced today, which has roots in the past, relates to the urbanization system. This entire area has been urbanized, and I believe that when the urbanization was planned and this area started to take shape, there was no consideration for the progress and advancements we see today."

Regarding drivers and operators, the findings provide complementary insights into how the system is structured and functions from the supply side.

In the area of governance, all three drivers/operators groups revealed that each organization or route operates with its own internal structure. In Chapinero (collective taxis), the focus was on a single route, allowing for detailed insights into its composition, including the number of vehicles, members, conflict resolution mechanisms, communication channels, and internal regulations. In Ciudad Bolívar (collective cars), collaboration among routes was emphasized as a strategy for managing problematic situations. In Kennedy (bicitaxis), despite the presence of cooperatives and federations, internal conflicts and organizational fragmentation have weakened collective structures. While Chapinero and Ciudad Bolívar maintain active relationships with formal institutions such as the Local Mayor's Office, the Police, the Ombudsman's Office, and the District Secretariat for Mobility, with special emphasis on collaboration with law enforcement, Kennedy is marked by a prevailing perception of state abandonment. It is also worth noting that drivers and leaders in Chapinero and Ciudad Bolívar express aspirations for formalization and seek recognition as key stakeholders in urban mobility. In Ciudad Bolívar, informal transport is referred to as 'alternative transport,' and in Chapinero, it is labeled as 'peripheral transport.' In Kennedy, bicitaxis are a primary source of income for vulnerable groups such as older adults, people with disabilities, and female heads of household:

"Many elderly people who can no longer get jobs, people with disabilities, and several women choose to work as informal drivers... women, because they come from situations of abuse in their households and they have separated, having 2 or 3 children, and the need to pay rent...Nobody gives them work because nowadays, if you have two kids, they don't give you work." (Kennedy driver participant).

"It's like the legal is not going to arrive... So, it would be good at least to recognize us or to remove that label of informal, the illegal ones" (Ciudad Bolívar driver participant).

Regarding the quality of service, a common concern in all three cases is the risk of vehicle impoundment during traffic enforcement operations. However, some drivers noted that such actions have become less frequent. In terms of road safety, leaders in Ciudad Bolívar believe the service to be safe. In Chapinero, risks are associated with overcrowding and the transport of underage passengers. In Kennedy, there is a pervasive perception of insecurity and a lack of protection for users. In terms of personal safety, Ciudad Bolívar and Chapinero offer relatively stable conditions, while Kennedy experiences frequent incidents of theft and vehicle robbery. Across all cases, the driver-user relationship is perceived as one of the most challenging aspects of the work:

"People can arrive at 10 p.m. and they know that they will not be in danger, that they will not be robbed... The community is very aware of this. A woman, a man, the driver alone, nothing is going to happen" (Ciudad Bolívar driver participant).

In the realm of operations, fares range between COP 1,000 and COP 3,000 (approximately USD 0.23-0.68), and service hours vary between 4:00 a.m. and 1:00 a.m., depending on the route and demand. Services include passenger transport, cargo delivery, and messaging, all of which are coordinated through walkitokies and WhatsApp groups. In Ciudad Bolívar, coverage expands in tandem with the emergence of new self-built neighborhoods. In Chapinero, community tensions arise due to the lack of access to conventional taxi services. Despite these differences, all three services operate along defined routes and stops, functioning as a complement to the formal transport system and as a means to facilitate caregiving-related travel. In Kennedy, the passenger defines the destination of each trip:

"This service has a specific purpose: it is solely intended for passenger transport... however, it also provides a freight service, ideally and preferably not in a mixed manner" (Kennedy driver participant).

Finally, in the area of contextual conditions, the main issue identified by drivers and operators across all cases is the inability of formal public transport to cover the last mile. Poor road infrastructure, insufficient maintenance and paving, and the challenging topography in peripheral areas necessitate the use of smaller, more flexible vehicles. In Ciudad Bolívar, the formal transport offer is limited; in Chapinero, the frequency of service is insufficient; and in Kennedy, the intense use of public

space and the scarcity of infrastructure lead to persistent congestion and urban saturation. One driver mentioned that:

“Where the bicitaxis operate, it is because the public service is deficient. What happens? The communities in all these sectors, in all the weaker parts, the poorer areas don't have public transportation” (Kennedy driver participant).

During the cartography process, user participants identified six facilitators and eleven barriers. They emphasized that the primary motivations for utilizing informal transport include complementing public transport, running local errands, and performing caregiving tasks. Conversely, drivers mapped four routes in the Ciudad Bolívar area: one served by 30 vehicles, another by 63 vehicles, a third with 38 cars and 12 motorcycles, and a fourth with six cars. In the Chapinero area, one route was identified with 53 vehicles, while in the Kennedy area, seven federations and several cooperatives were noted as operating. Figure 5 visually presents the main barriers and enabling factors identified during this process, including the common points.

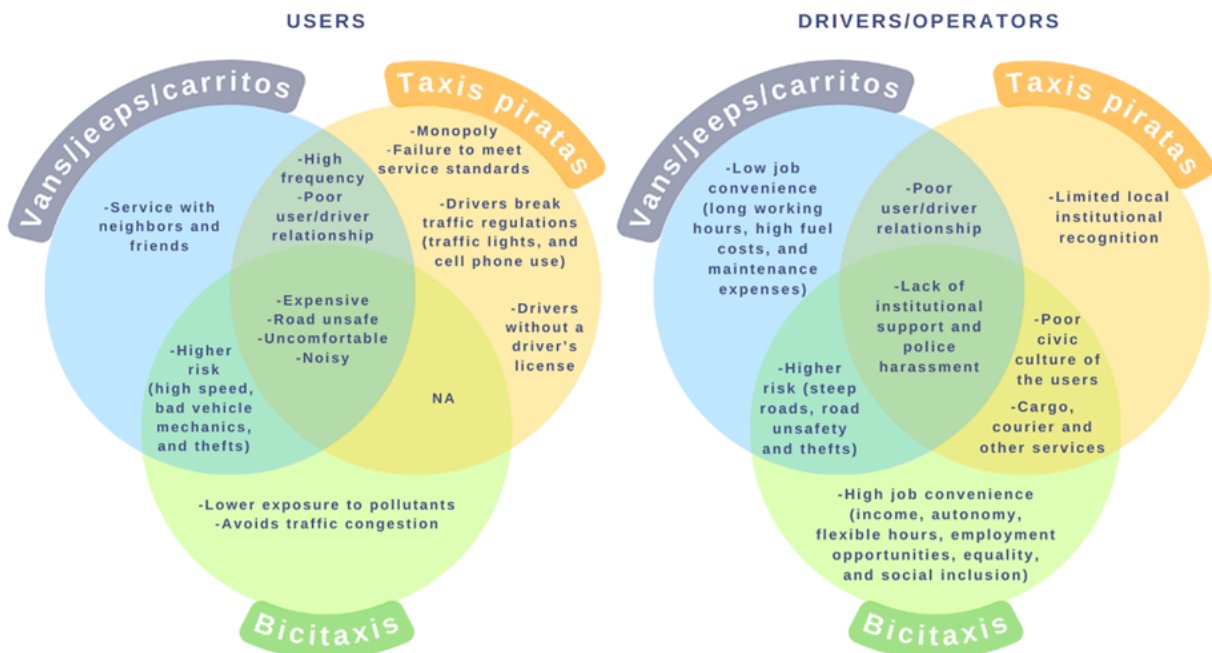


Figure 5. Social cartography findings

Users across the three case studies consistently identified three key concerns: the financial burden of the service (affordability), the comfort conditions during trips, and the safety risks associated with inadequate infrastructure and vehicle maintenance. As for facilitators, users in Ciudad Bolívar (collective cars) and Chapinero (collective taxis) noted the strained relationships between users and

drivers. In both Ciudad Bolívar and Kennedy (bicitaxis), users expressed heightened concerns regarding the risks posed by the condition of the roads and vehicles. Specifically, in Chapinero, users pointed out that pirate taxi operators functioned like a monopoly, failed to meet service standards, violated traffic regulations (such as ignoring traffic lights and using mobile phones while driving), and, in some cases, operated without proper driver's licenses. On the other hand, in Ciudad Bolívar, users emphasized the social aspect of using ISM, often traveling with friends and neighbors. The high frequency and express nature of the service were also noted, a point echoed by users in Chapinero. In Kennedy, users appreciated the reduced exposure to pollutants and the ability to avoid traffic congestion when using ISM.

On the other hand, drivers and operators across the case studies shared concerns regarding the lack of formal recognition of their work, limited institutional support, and ongoing police persecution. In Kennedy, drivers highlighted the greater convenience of their labor, noting benefits such as income, autonomy, flexible hours, employment opportunities, and social inclusion. In contrast, drivers in Ciudad Bolívar reported lower labor convenience, citing long working hours and high operational costs as significant challenges. In both Ciudad Bolívar and Chapinero, drivers and operators also acknowledged the poor relationships between users and drivers. Additionally, drivers in Ciudad Bolívar and Kennedy pointed to the risks associated with steep slopes and the poor condition of the roads. Kennedy and Chapinero mentioned the poor civic culture among users and emphasized that informal transport often serves not only as a means of passenger transport but also as a means for cargo, courier, and other services. Finally, bicitaxi drivers noted strained relationships with colleagues who engage in drug use, a situation attributed to their young age and early entry into the sector, where they started earning money.

Based on all these findings, three key areas of concern emerge for both ISM users and operators: road safety, community-level conflicts, and the broader need for institutional recognition of informal transport as a legitimate actor within the urban mobility system. These thematic priorities provide the foundation for the proposed methodological structure of the Urban Living Lab for ISM in Bogotá.

5.2 Proposing a living lab methodology to co-produce interventions

Building on the insights generated during the participatory diagnosis phase, the Bogotá ISM Living Lab designed a structured methodology for its core intervention phase: the co-production of solutions within thematic working groups. This methodology operationalises the ToC framework, previously introduced, transforming it into a practical, staged process for collaborative problem-solving and intervention design. This approach ensures that interventions align strategically with

collectively defined goals and are grounded in the lived realities identified during the diagnosis, building a pathway from understanding to action. The proposed methodology unfolds across several distinct, sequential stages, designed to be facilitated within the Working Group workshops:

Stage 1: Problem identification and scoping. The process is initiated by grounding the discussion within the specific context of each ISM case study and the broader findings from the diagnostic focus groups. Participants collectively revisit the key challenges identified, focusing on predefined thematic axes such as road safety, community conflicts, or the recognition of informal transport themes, which are derived directly from the issues most frequently raised by users and operators. Within their chosen theme, each working group collaborates to discuss and prioritise a specific, core problem they wish to address, ensuring the subsequent work is focused and relevant to pressing local concerns. This stage also involves clarifying the scope and limitations of the Living Lab project itself.

Stage 2: Defining the long-term impact goal. Once a specific problem is selected, the group works together to articulate a clear and compelling long-term Impact goal. This involves answering critical questions: What specific change is desired? For whom is this change intended? How will this change manifest? Where and, potentially, by when should this change occur? Crafting this shared vision provides a clear destination for the group's efforts and serves as the anchor point for the backward mapping process inherent in the ToC methodology.

Stage 3: Mapping preconditions and identifying necessary effects. With the long-term impact defined, the methodology guides participants to work backwards, identifying the crucial intermediate outcomes or effects that must be achieved for the impact goal to be realised. This stage encourages systemic thinking by prompting participants to consider necessary changes across multiple levels.

- Personal Level: What changes in attitudes, knowledge, skills, or behaviours are needed among individuals (e.g., drivers, users, officials)?
- Community/Neighbourhood Level: What changes are required in social dynamics, community organisation, or local interactions?
- Environmental Level: What changes are necessary in the physical or operational environment (e.g., infrastructure, vehicle conditions, service routes)?
- Public Policy Level: What shifts are needed in regulations, enforcement, institutional recognition, or governance structures? The group collectively

identifies and prioritises the most critical effects at each level, constructing a plausible causal pathway leading towards the desired impact.

Stage 4: Defining tangible products and strategies. This stage translates the identified effects into concrete products. These are defined as the tangible outputs, methods, tools, or actions that the ULL can realistically develop or facilitate within its timeframe and resources to contribute directly to achieving the prioritised effects. Examples discussed during the design phase include developing sensitization campaigns on road safety, creating platforms for dialogue between operators and policymakers, or producing policy briefs that outline specific recognition challenges and proposals. The focus here is on feasibility and direct contribution to the mapped change pathway.

Stage 5: Detailing specific activities. For each defined product, the working group then breaks it down into the specific, actionable activities required for its realisation. This involves detailed planning. For instance, based on the insights from the diagnosis, we identified an interest in improving public awareness about the role of ISM. In response, the group work can focus on activities such as outlining the steps to design and implement a sensitisation campaign (e.g., defining methodology, recruiting participants, conducting sessions) or the logistical planning required for a policy dialogue event. This detailed mapping ensures clarity on the operational steps needed to move forward.

Stage 6: Identifying necessary inputs and roles. The final stage focuses on identifying the Inputs required to undertake the planned activities successfully. This includes specifying essential human resources and defining clear roles for different actors (e.g., community members, operators, public sector representatives, academic partners), as well as identifying required physical resources (e.g., workshop materials, venues) and potential financial needs. This step grounds the plan in practical considerations of resource availability and stakeholder contribution.

This ToC-based methodology facilitates a rigorous, transparent, and participatory process for co-designing interventions by guiding stakeholders through structured stages. It ensures that proposed solutions are responsive to identified needs and strategically linked to achievable outcomes and a shared vision for long-term positive change within Bogotá's informal and shared mobility landscape. The implementation of two working groups is proposed, one for each actor type considered in the study: users on the one hand, and drivers and operators of the ISM on the other, without distinguishing between specific case studies. These sessions aim to identify concrete outputs and required actions to address and foster community-level improvements

in the areas identified as principal thematic axes in the ISM diagnosis for Bogotá: road safety, community conflicts, and the recognition of informal transport. Participants from the three case studies will participate in the working groups and will rotate systematically across three workstations, each dedicated to one of the identified thematic axes. At each station, they will engage with the different methodological stages previously outlined, according to the corresponding thematic focus.

These two sessions focus on the proposal and co-creation of interventions. However, it is essential to involve policymakers in evaluating and assessing the feasibility of these proposals during the formulation phase. Therefore, it is recommended that, once the community-driven outputs have been developed, a third session be held to present and discuss these proposals with decision-makers and local institutions. This additional step aims to better align the interventions with institutional capacities and the priorities of local governments, thereby enhancing the relevance, feasibility, and overall impact of the Living Lab's outcomes and thus providing a practical participatory toolbox for designing environmentally and socially sustainable mobility futures in the city.

6. Discussion

This paper details the methodological proposal of the Bogotá ISM Living Lab, outlining a framework intended to bridge participatory diagnosis with collaborative action. The process, grounded in Urban Living Lab principles and structured by a Theory of Change approach, seeks to address the complexities surrounding diverse ISM services (i.e., collective cars, 'pirate' taxis, and bicitaxis) operating within distinct socio-spatial contexts in Bogotá. Three core insights emerge from this design process regarding the effective establishment and structuring of such collaborative platforms for ISM innovation.

First, the study supports the need for a participatory, co-produced diagnosis as a foundational step for establishing a feasible and legitimate structure for collaboration. Engaging directly with the complexities of ISM, particularly in contexts marked by informality, poverty, varying governance structures, and potential distrust between actors, requires more than external assessment. The initial phase, employing focus groups and social cartography with users and operators across the three distinct case studies, proved essential for generating a grounded understanding. This process moved beyond generic assumptions about informal transport, revealing specific local dynamics, operational realities, and stakeholder perceptions that include ambiguities in governance understanding and varied service

quality assessments. It also revealed key context-specific challenges, like infrastructure deficits or community conflicts. This aligns with arguments emphasising community engagement and understanding local power dynamics when applying participatory methods in complex urban settings (Williams et al., 2016). Without deeper and collaboratively generated diagnostic insights, a Living Lab structure that resonates with participants and addresses relevant issues risks being ineffective or counterproductive. The diagnosis directly informed the identification of key thematic axes for the Lab's subsequent work, such as road safety, community conflicts, and institutional recognition. These topics ensure that the proposed structure is anchored in priorities voiced by the community. This process highlights that for ULLs tackling informality in Global South contexts, co-diagnosing issues and challenges cannot be separated from co-designing the platforms for addressing them.

Second, the analytical framework employed during the synthesis phase, which enabled us to structure insights around Governance, Quality of Service (QoS), System Operations, and Contextual Conditions, helped us to unpack the nuances of different ISM services. Applying this framework systematically across the three study cases allowed for a structured comparison, revealing commonalities (e.g., perceived failures of formal transport) and critical distinctions. For example, governance structures ranged from relatively coordinated routes in Ciudad Bolívar to single ownership in Chapinero and fragmented cooperatives in Kennedy. QoS perceptions varied dramatically, from generally positive regarding frequency and cost in Ciudad Bolívar and Kennedy to highly negative concerning driver behaviour in Chapinero. Operational analysis highlighted different functions, from clear feeder roles (Ciudad Bolívar, Chapinero) to more flexible, taxi-like services (Kennedy and Bosa). This structured disaggregation moves beyond monolithic views of 'informal transport' (Behrens et al., 2016). Importantly, it enables the identification of specific leverage points for potential interventions tailored to each context. Understanding the particular governance challenges in Kennedy versus Chapinero, as well as the differing user priorities regarding QoS, will enable the ULL to target future experiments more effectively, focusing on the levers and pulls most relevant to fostering cooperation and achieving impact within each system. This diagnostic nuance, facilitated by the framework, is appropriate for designing potentially impactful pilots rather than applying generic solutions.

Third, the proposed integration of the ToC framework within the ULL structure offers a robust approach for bridging research insights with collaborative action planning. While the ULL provides the essential participatory space and ethos for engaging diverse actors (Hossain et al., 2019), the ToC methodology supplies the

strategic roadmap needed to navigate the complexities of intervention design within informal systems. The proposed staged process for the working groups, which enables a progressive and systematic transition from problem identification and impact definition, to the backward mapping of effects across multiple levels (personal, community, environment, and policy), and finally to defining products, activities, and inputs, provides participants with tangible conceptual and strategic tools. It equips diverse stakeholders (community members, operators, officials) with a shared language and logical structure to articulate pathways to change, identify necessary actions within the Lab's scope, define roles, and consider resource needs. This contrasts with less structured participatory approaches that sometimes struggle to translate dialogue into actionable strategies. By explicitly mapping assumptions and causal links, the ToC approach embedded within the ULL fosters transparency. It provides a basis for adaptive management and evaluation as the Lab moves into its experimental phase. This structured yet flexible combination appears well-suited for promoting the integration of research and action required to address the deeply embedded challenges of ISM governance and operation, aligning local experiments with broader goals of sustainable and inclusive urban mobility.

While the methodological development presented in this paper provides a valuable foundation for participatory engagement with ISM systems, it presents limitations that must be considered in future applications. Focus group participants were primarily drawn from user groups with greater familiarity and a willingness to participate in transport-related participatory spaces, which limited the inclusion of younger populations and other underrepresented voices. Moreover, contextual barriers, such as limited resources and initial distrust, affected community engagement during the diagnostic phase, potentially influencing both participation levels and the representativeness of identified priorities. To mitigate this, the fieldwork was conducted by facilitators with previous experience in the territory and prior contact with community members in the study cases, which helped build trust and facilitate dialogue. Additionally, the scope of the initiative was shaped by the academic nature of the institution leading the study, necessitating the clear communication of the project's objectives, limitations, and the extent to which it could produce actionable outcomes, particularly in terms of the feasibility and implementation of proposed strategies or products. Finally, the practical application of the proposed methodology depends on sustained inter-institutional collaboration, particularly with public agencies and local entities, to ensure institutional support and assess the viability of the proposed interventions.

7. Conclusions

This paper outlined the step-by-step method of the Bogotá Informal and Shared Mobility Living Lab, presenting a framework grounded in participatory diagnosis and structured by a Theory of Change approach. The process detailed here demonstrates a pathway for moving from understanding the complexities of diverse ISM systems towards establishing a collaborative platform for co-designing interventions. The main contribution lies in articulating a replicable methodology for initiating and structuring ULLs focused on transport informality in challenging urban contexts.

The potential of this integrated ULL-ToC approach is significant. It offers a mechanism to engage directly with often-marginalised transport operators and communities, fostering trust and incorporating invaluable local knowledge into problem analysis and solution design. The framework facilitates structured dialogue among diverse stakeholders with potentially conflicting interests, guiding them towards shared goals and actionable strategies. This approach holds promise for generating context-specific innovations and informing more inclusive, adaptive transport governance models relevant not only to Bogotá but also to other cities across the Global South grappling with similar ISM dynamics.

Central to the success of this approach is the foundational value of participatory diagnosis. The detailed understanding of governance nuances, service quality perceptions, operational realities, and contextual factors across the different case studies, generated collaboratively with users and operators, was indispensable. This grounded diagnosis ensured that the subsequent design of the Living Lab structure and the ToC-based intervention methodology were relevant, credible, and targeted towards issues prioritised by the stakeholders. It highlights that investing time and resources in collaborative diagnosis is a prerequisite for building legitimate and potentially effective platforms for change in complex urban systems.

This paper, however, focuses primarily on the design phase of the Bogotá ISM Living Lab. While the methodology holds promise, its practical implementation and ultimate impact remain subjects for future research. Key areas for subsequent investigation include tracking the execution of the Working Groups using the proposed ToC methodology, analysing the nature and feasibility of the interventions co-designed by participants, and evaluating the outcomes of any implemented pilots. Understanding how the Lab navigates power dynamics during implementation, secures sustained stakeholder engagement, and influences formal policy processes will be crucial for its success. Assessing the long-term sustainability of established collaborative structures and the adaptability of the methodology will provide valuable lessons for

applying participatory approaches to informal transport governance, operations, and the co-production of interventions in other contexts.

Supplementary Material

Table S1 shows the main socioeconomic characteristics of the focus group participants.

Table S1. Focus group participant descriptions

	<i>Ciudad Bolívar</i>				<i>Chapinero</i>				<i>Kennedy/Bosa</i>			
	<i>Users</i>		<i>Drivers/Operators</i>		<i>Users</i>		<i>Drivers/Operators</i>		<i>Users</i>		<i>Drivers/Operators</i>	
	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
Sex												
Male	4	40	8	80	4	44.4	0	0	1	50	8	80
Female	6	60	2	20	5	55.6	9	100	1	50	2	20
Age												
Mean (SD)	10	58 (11)	10	55 (13.3)	7	54 (20.4)	8	42 (15.6)	2	24 (3.5)	10	59 (11)
Monthly household income												
≤ 1 MMW	5	50	4	40	0	0	3	33	0	0	3	30
>1- ≤ 2 MMW	1	10	3	30	2	22.2	3	33	0	0	4	40
>2- ≤ 3 MMW	0	0	1	10	2	22.2	1	11	0	0	1	10
>3- ≤ 4 MMW	0	0	2	20	0	0	1	11	2	100	0	0
> 4 MMW	0	0	0	0	0	0	0	0	0	0	0	0
NR	4	40	0	0	5	55.6	1	11	0	0	2	20
Occupation												
Working	5	50	8	80	4	50	8	88.9	2	100	7	70
Studying	0	0	0	0	0	0	0	0	0	0	0	0
Household activities	2	20	0	0	2	25	0	0	0	0	2	20
Care	1	10	0	0	0	0	0	0	0	0	1	10
Not working	0	0	1	10	1	12.5	0	0	0	0	0	0
Others	2	20	1	10	1	12.5	1	11.1	0	0	0	0
Education level												
Elementary	5	50	3	30	1	11.1	2	22.2	1	50	4	40
High school	4	40	6	60	3	33.3	4	44.4	1	50	3	30
Technical/Technological	1	10	0	0	2	22.2	1	11.1	0	0	3	30
University	0	0	0	0	0	0	0	0	0	0	0	0
Postgraduate	0	0	1	10	0	0	0	0	0	0	0	0
None	0	0	0	0	1	11.1	1	11.1	0	0	0	0
NR	0	0	0	0	2	22.2	1	11.1	0	0	0	0

* 1 Minimum monthly wage (MMW) = \$ 1,300,000 COP (295 USD)

On the other hand, Table S2 shows the thematic analysis by category and subcategory.

Table S2. Data analysis categories and subcategories

Category	Subcategory	Level	Definition
A - Governance	A1 - Organization	Community	This refers to the level of organization of the different routes and cooperatives within the informal transport modality.
	A2 - Relationships	Interpersonal	This encompasses the dynamics that arise in the relationship between drivers, leaders, and route owners, with particular attention to internal power relations.
	A3 - Aspirations	Individual	This refers to the aspirations of drivers in terms of being socially recognized as key actors in the city's mobility. It also encompasses their perspective on the processes and possibilities for formalizing their work.
	A4 - Community Ties	Community	This indicates the processes of self-organization and community self-management to address mobility barriers in their context. It also considers the relationships between different actors (formal-institutional).
B - Quality of Service (QoS)	B1 - Exposures/Risks	Individual, Interpersonal, Community, Built Environment, Public Policy	This refers to the risks related to public safety (theft, harassment, and robberies) and road safety (accidents) that occur on the streets and in the vehicles. It also includes concerns about air quality and health.
	B2 - Trust	Interpersonal	This indicates the perceptions of the level of trust established between users, drivers, and members of the community in general regarding the informal transport service.
	B3 - Convenience	Individual	This encompasses aspects related to preferences in choosing the mode of transport, such as travel times, distances, comfort, among others.
	B4 - Travel motives	Individual	This refers to the main activity and/or motivation for travel using informal transport, taking into account a differential approach.
	B5 - Drive/user relationship	Interpersonal	This refers to situations of conflict, strengthening of bonds, and coexistence between users and drivers.
C - System Operations	C1 - Routes, stops, and frequency	Organizational	This indicates the details related to the routes, stops, and frequencies of the different informal transport systems.
	C2 - Fare	Organizational	This encompasses the fare dynamics based on distances and the times (schedules) when the informal transport service is offered. It also addresses who sets the fares (the fact: what is charged, and the process: with whom the fare is agreed upon).
	C3 - Types of services	Organizational	This indicates the types of services offered by informal transport, such as passenger transport, cargo, and courier services, among others.
	C4 - Technology	Organizational	This indicates the technological tools used by the organizations that provide informal transport services.
	C5 - Coverage	Organizational	This includes aspects related to the coverage of the various routes offered by informal transport, considering users' access times and distances.
	C6 - Vehicle types	Organizational	This indicates the types of vehicles used by the different informal transport systems.
	C7 - Schedules	Organizational	This gathers information on the operating hours of informal transport routes.
D - Contextual Conditions	D1 - Public transport	Public Policy, Built Environment	This compiles users' perceptions of the public transport system, including its advantages, limitations, and recommendations for public policy improvements.
	D2 - Infrastructure	Public Policy, Built Environment	This refers to the current condition of the built environment and its role in enabling or constraining mobility in Bogotá.
	D3 - Urban planning	Public Policy, Built Environment	This addresses perceptions of institutional involvement in urban planning and its relationship to land use for mobility purposes.

Table S3 provides an overview of the main findings from the user focus groups in each case study.

Table S3. Users' focus group results

	Case 1: Collective cars (Ciudad Bolívar)	Case 2: Pirate taxis (Chapinero)	Case 3: Bicitaxis (Kennedy)
Governance	Users lack clarity about the number of routes and the internal structure of the informal transport service. There is a general idea, but no in-depth understanding. They are unaware of how service-providing organizations operate. They know there are route owners, employed drivers, and assistants. Users call for increased dialogue between institutions and stakeholders. They recognize that informal transport addresses key needs, especially given poor road conditions. The community has attempted to engage in mobility discussions through meetings with district institutions. They perceive few tangible outcomes, with TransMiCable being the only significant result mentioned.	Users perceive a significant lack of organization in the informal transport service. They have no clear understanding of how the system is structured. Users highlight the youth of the drivers as a notable aspect. They emphasize the need for dialogue spaces with service providers to enhance trust and address customer needs. Meetings have been held with government entities to discuss transportation. There is a perception of inequality: wealthier areas are favored, while more vulnerable neighborhoods, such as Pardo Rubio, are often overlooked.	Vehicles are typically owned by individuals who hire drivers and pay them based on the time spent providing the service. There is no mention of interaction with government entities or proposals for direct dialogue with service providers. Users consider bicycles and cycle taxis ideal options due to their reduced congestion and faster service. They propose promoting their use from early childhood through educational programs.
Quality of Service (QoS)	There is a constant fear of potential accidents due to the poor condition of vehicles. Vehicles are perceived as failing to meet required mechanical and safety standards. There is widespread distrust of the service and its drivers. Although drivers are from the same neighborhood, it is believed that mechanical inspections are manipulated. The system is considered valuable and convenient due to its high frequency. Its main uses are related to caregiving and running errands for medical purposes. Women and community leaders are the primary users due to their constant mobility in the area. There is a strong relationship between users and drivers owing to community bonds.	Users associate risks with tampered licenses and irregular permits. Community leaders feel unsafe speaking out, even within their own neighborhoods. There is low trust in drivers due to fears of mistreatment or aggressive behavior. Drivers are described as unempathetic, rude, and lacking a service-oriented attitude. Although high frequency is seen as a benefit, users would avoid the service if alternatives were available. Drivers begin trips only when the vehicle is full. The service is a basic necessity for accessing work, education, healthcare, and markets, particularly in the Pardo Rubio area. There is marked tension; users feel mistreated or unsafe. Instances of harassment and verbal abuse by drivers have been reported.	The main concern is speed and poor road conditions, rather than general urban insecurity. Users feel that drivers speed excessively to complete more trips, leading to discomfort and physical risk (such as jolts from potholes and speed bumps). The short trip duration is appreciated compared to other services. The size of the cycle taxi allows for the use of bike lanes and car roads to complete routes more efficiently. Not all users feel safe with the service; for instance, older adults tend to avoid it due to stress and feelings of insecurity. It is mainly used for medical errands or short local trips within the locality.
System Operations	Routes and stops are well-defined in the locality, and users are familiar with their locations, which are usually near their homes. Fares range from 1,000 to 1,500 COP depending on the route. Night shifts have different pricing. Primarily serves as a feeder to the public transport system (PTS). Also used for hauling and short local trips. There is no technological mechanism to request the service; all interactions are in person. It offers broader coverage than formal public transport. Although routes are predefined, users can negotiate specific destinations for an extra charge. The service is operated by companies using minibuses with a capacity of up to 10 passengers. Each route has a name, and some organizations have a brand identity recognized by the community. The service operates throughout the day until 11 PM.	Routes and stops are clearly defined and widely known by users. They are generally located near users' homes, encouraging service use. Despite minor variations, the routes follow a logic that is familiar and useful to the community. The community is aware of standard fares, but some drivers are reportedly overcharging. Necessity is the primary reason for continuing to use the service. Passenger transport is predominant. Cargo and delivery services are uncommon, as drivers typically do not allow them. No technological system is used to request the service. Coverage is greater than that of public transport. Drivers rarely deviate from established routes. In the Pardo Rubio neighborhood, ISM is operated by a company that exclusively uses collective taxis. The service runs throughout the day, including early morning hours.	Several companies operate in different sectors of the locality. Users are aware of specific pick-up points; cycle taxis are required to park in designated areas. Each organization has exclusive routes that are not shared with others. The service is direct: once a journey begins, the driver takes the passenger directly to the final destination without making any additional stops. The minimum fare is COP 4,000 and varies depending on distance. It is seen as significantly cheaper than a taxi. Services primarily include passenger transport and small cargo delivery. Courier services are neither mentioned nor offered. There is no technology to request the service. Users access it directly from the stops by waving their hand. Users believe an app should be implemented to make requests easier. Vehicles are adapted bicycles with a canopy, later fitted with a motor to reduce the physical effort required of the driver.
Contextual Conditions	Public transport is heavily criticized for its limited coverage, forcing many people to rely on informal transport. Recent efforts to improve infrastructure through architectural recovery projects are acknowledged. Physical conditions, such as steep hills and narrow roads, hinder mobility and fail to provide optimal transport conditions. Users feel that urban planning is inadequate. The locality grew rapidly and disorderly, without anticipation of future mobility and urban space needs.	Public transportation is perceived as deficient, with low frequency and poor response during peak hours. Previously, the area had at least four bus routes, but now only two remain, resulting in reduced mobility. The neighborhood's infrastructure—with its narrow streets and challenging topography—has negatively impacted service quality. The neighborhood is located in a high-mountain area with narrow roads that hinder access. Perceived insecurity has also limited access to services like Uber and ambulances, which avoid entering the area. Users believe that the district has not prioritized their needs. They argue that government decisions have reduced transport options without community consultation, deepening mobility exclusion.	Users acknowledge that public transport is essential for the city's functioning, but it is seen as problematic due to high demand. Overcrowding in TransMilenio (BRT) vehicles is a common complaint, making the experience uncomfortable and stressful. The general perception is that the city's urban infrastructure is inadequate to support proper mobility. It is noted that the city's physical conditions hinder the efficient delivery of transport services.

Finally, Table S4 presents a general summary of the results for the case of drivers/operators.

Table S4. Drivers/operators' focus group results

	Case 1: Collective cars (Ciudad Bolívar)	Case 2: Pirate taxis (Chapinero)	Case 3: Bicitaxis (Kennedy)
Governance	Participants were leaders of routes in San Francisco, Bella Flor, Paraíso, and El Lucero, representing 4 to 5 routes. There is mutual support among operators in problematic situations, with respect for routes and stops. Operational autonomy: each route defines its own internal operations, driver requirements, and community activities. Drivers feel valued for meeting transport needs, offering flexible schedules, varied services, and cost savings. They identify as "alternative transport" to combat the stigma of being informal or "pirate" services. Although they wish to formalize, they are skeptical about the feasibility and mutual benefits of doing so. They seek recognition as key actors in urban mobility. They maintain direct contact with the Local Ombudsman's Office, Local Mayor's Office, Police, and District Mobility Secretariat to demonstrate their importance in city transport.	The route is composed of 53 vehicles, 7 leaders (drivers or vehicle owners), and 2 fare collectors. Coordination is done via WhatsApp to communicate and notify about passengers. On weekends, another group of community drivers shares the same route. Vehicle owners rent cars to drivers, covering insurance, tires, and fuel costs. To operate, drivers must be part of the community, follow the rulebook, and ensure a quota of 8,000 users per vehicle. Internal conflicts are resolved among leaders, and if needed, decisions are made by vote. Non-compliance results in sanctions, including expulsion or the denial of admission to new members. Leaders and drivers believe their work fills gaps not addressed by the state, especially in peripheral areas. The route has been operating for 47 years, initially using vans and jeeps, and later partially formalized with the addition of taxis. The route owner defines it as "peripheral transport." They have worked with the local mayor's office and local councilors to improve conditions and have also collaborated with the police. Although they have faced challenges, leaders have actively addressed issues and improved service over the past five years. They cooperate with a new police commander to process community petitions regarding the service.	There are disputes among different cooperatives and cycle taxi groups, sometimes triggered by migration or the displacement of corporations by criminal groups. An individual may operate within a cooperative's route, generating internal conflict. Disagreements exist over regulations, service types, and organizational structure. There is also a lack of clarity regarding payments to legal representatives. Conflicts arise due to the presence of people using psychoactive substances in the work environment. Informal transport generates income for people with disabilities, elderly individuals, and single mothers. The problems faced by cycle taxi drivers reflect state neglect and labor precarization. Some leaders report having engaged in dialogue with the Ministry of Transport and the Mobility Secretariat for over 18 years, with no concrete outcomes. The high number of cycle taxis and lack of organization exacerbate conflicts and hinder the formalization of the service.
Quality of Service (QoS)	Drivers report that although traffic incidents have occurred, there have been no fatalities. Vehicles and individuals are not at high risk of theft or assault. Vehicle impoundment remains a constant concern, although it has decreased over time. Several route leaders report that one of the most challenging aspects of their work is the relationship with the driver-users.	Drivers face road safety risks due to fare evasion by children or passengers insisting on overcrowding. Service provision carries the risk of vehicle impoundment by traffic authorities. Many users, especially those working in restaurants, bars, and nightclubs, prefer taxis for their greater comfort. Drivers are expected to serve vulnerable individuals (the elderly, people with disabilities, and emergency cases), but this often creates conflict with other users due to differences from standard taxi services (such as destination flexibility, passenger capacity, and neighborhood coexistence).	Drivers cannot guarantee passenger safety in the event of an accident. Cycle taxis are subject to theft and robbery, and drug use and sales occur within the service environment. A positive relationship has been established with the community, which has helped improve service quality. Most trips serve as feeder routes to TransMilenio stations, followed by trips to kindergartens, health centres, and local markets. Primary users are adults, people with disabilities, and children. Communities have requested improvements in vehicle quality and the personal presentation of drivers.
System Operations	The ISM plays a key role in connecting to TransMiCable stations. Each route sets its own fares, which range from 1,000 to 3,000 COP, adjusted to local economic needs and ability to pay. Routes offer passenger transport, cargo services, and deliveries. Radios and WhatsApp groups are used to coordinate routes. Coverage expands based on mobility needs in new neighborhoods, rural zones, or areas affected by the removal of formal routes. Vans or minibuses with capacities of 10–12 passengers are used—ideal for areas with poor access or requiring detours due to blockades. Route leaders affirm that all paperwork is in order, including insurance and mechanical certification. Operating hours vary by route, with some working from 4 AM to 11 PM.	There is a single route with multiple designated stops. Fares are 2,000 COP for the uphill direction and 1,500 COP for the downhill, with no night or holiday surcharge. Taxis only operate up to Seventh Avenue, causing issues since they do not complete passengers' journeys. Taxis are legally registered and have the necessary documentation to provide public transport services, albeit individually. The service operates from 4:30 AM to 1:00 AM.	Drivers did not identify specific map points, but each cooperative has assigned stops. Passengers set the destination. Some cooperatives offer passenger transport, courier services, and moving services. The service helps meet demand for BRT stations such as Portal Americas, Patio Bonito, Biblioteca Tintal, and Banderas. Vehicles include traditional bicycles, combustion-engine bikes, and electric motorbikes; however, many drivers prefer combustion engines for their functionality. Schedules vary among drivers, with working hours ranging from 4 to 10 hours per day.
Contextual Conditions	Public transportation is reported to be insufficient, with limited available options and no coverage in outlying rural areas. There are not enough roads to accommodate the current population, and many areas lack proper maintenance and paving, resulting in heavy traffic. The lack of urban planning has made access to essential services, such as ambulances, more difficult. There is a perception that the state focuses only on immediate problems and fails to plan for long-term needs, thereby ignoring future mobility requirements.	In addition to topographic challenges, urban planning is often described as deficient, with insufficient roads and inadequate infrastructure to meet current demand.	The main issue is that public transport fails to address last-mile connectivity. There is a noted lack of urban planning to regulate public space uses, such as the number of cycle taxis, street vendors, and the absence of civic culture.

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