Data-Driven Mobility Planning as a Mediating Infrastructure: Big Data, AI, and Intergenerational Participation in the Lake Chapala Region, Mexico

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Abstract. This Regional mobility planning increasingly faces challenges in territories characterized by environmental sensitivity, fragmented governance, and multi-municipal coordination. In these contexts, mobility systems operate as complex socio-technical arrangements shaped by interdependent travel behaviors, land-use patterns, and institutional dynamics across scales. Although data-driven tools are often presented as objective solutions, limited attention has been given to how different sources of information interact within actual planning processes. This paper asks how data-driven tools can support regional mobility planning when combined with survey-based methods and participatory processes.

The study analyzes the 2025 Lake Chapala Regional Mobility Plan in Mexico, a multi-municipal initiative encompassing several jurisdictions surrounding the country's largest lake. The methodology integrates Big Data analysis, AI-assisted traffic counts, and geospatial modeling with origin–destination surveys and participatory workshops involving technical teams, municipal authorities, and local communities.

These workshops were structured under a "Seven Generations" framework to incorporate intergenerational perspectives into mobility decision-making. Findings indicate that Big Data revealed regional mobility patterns and temporal dynamics, surveys provided socio-demographic and behavioral insights, and participatory workshops enabled contextual interpretation and validation of technical results. Rather than replacing deliberation, data-driven tools functioned as mediating infrastructures that structure dialogue and facilitate coordination among municipalities.

The Lake Chapala case demonstrates that integrating digital analytics, surveys, and participatory processes can strengthen inter-municipal coordination and enhance the legitimacy of regional mobility planning outcomes.

Keywords: Data-driven urbanism, Mobility Planning, Regional urban planning, Participatory planning.

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1 Introduction

Regional mobility planning in environmentally sensitive and institutionally fragmented territories presents distinctive methodological and governance challenges. In such contexts, mobility operates not merely as a technical system of infrastructure provision, but as a socio-territorial process shaped by intermunicipal interdependencies, productive dynamics, environmental constraints, and unequal access to services. The Lake Chapala region in western Mexico (Fig. 1) exemplifies this condition: a functionally integrated yet administratively divided territory where daily mobility flows exceed municipal boundaries and intersect with ecological vulnerability and multi-level governance complexities.

Fig. 1. Lake Chapala region location
Source: (Authors' own elaboration, 2026)

In recent years, data-driven urbanism has positioned Big Data and artificial intelligence as powerful instruments for enhancing transport planning, offering unprecedented spatial and temporal coverage. However, the growing availability of digital traces has also raised questions about representativeness, interpretation, and the relationship between technical evidence and lived experience. This article examines how heterogeneous methodological systems interact within an actual regional planning process.

Drawing on the 2025 Lake Chapala Regional Mobility Plan, the paper analyzes how Big Data analytics, AI-based traffic counts, origin–destination surveys, logistics

surveys, and intergenerational participatory workshops were articulated to support decision-making. It argues that their combined application functioned as a mediating infrastructure, structuring dialogue, enabling shared diagnoses, and translating complex data into coordinated multiscalar interventions.
Existing literature on data-driven mobility planning has tended to focus either on the technical capacities of digital datasets and AI-based tools, or on broader critiques related to algorithmic bias, representation, and smart mobility governance. Less attention has been paid to how these tools are operationally combined with traditional surveys, fieldwork, and participatory processes within real planning exercises, particularly in non-metropolitan regions characterized by environmental sensitivity, fragmented governance, and uneven institutional capacities. As a result, the role of data-driven tools as mediators between technical evidence, institutional coordination, and situated community knowledge remains underexplored.
The article contributes to ongoing discussions on the role of data-driven approaches in territorial planning by situating digital mobility analysis within a broader framework of methodological complementarity and governance mediation. While Big Data has expanded the analytical capacity of planners, its effective application depends on how it interacts with other forms of knowledge production, including field observation, social research, and participatory processes. In territorially fragmented regions such as Lake Chapala, where mobility patterns extend across multiple jurisdictions and intersect with environmental and economic transformations, the integration of these diverse sources of information becomes particularly relevant.

2 Conceptual Framework: Mediating Infrastructures in Mobility Planning

Mobility, as a central dimension of planning, enables access to activities, services, and opportunities across multiple spatial scales. It involves the organisation of decisions and priorities that shape territorial functioning and everyday life. As mobility patterns extend beyond administrative boundaries, mobility planning necessarily operates across multiple scales, requiring interinstitutional coordination among different levels of government and actors with uneven capacities.

Historically, mobility planning has relied on specific traditional data collection methods, including origin–destination surveys, household travel surveys, and traffic counts. These instruments have enabled the characterisation of travel behaviour, the identification of general patterns, and the calibration of transport models. However, the specialised literature highlights significant limitations in their ability to capture temporal variability and evolving demand dynamics, as well as their strong dependence on aggregated data and sensitivity to input errors (Ortúzar & Willumsen, 2011).

In recent decades, new technologies associated with data-driven urbanism have been progressively incorporated into planning practice. Data-driven urbanism refers to an approach to urban planning that mobilises data and empirical analysis to inform decision-making related to urban design, management, and policy (Kitchin, 2014).

Within this context, Big Data, understood as information sets characterised by high volume, velocity, and variety (Torre-Bastida et al., 2018), has been widely adopted in the field of mobility to address some of these limitations. In practice, these data are commonly used as inputs for modelling, including the construction of origin–destination matrices and the development of strategic transport and land-use–transport interaction (LUTI) models.

One of the primary advantages of Big Data lies in its capacity to generate information at a scale and level of representativeness that would be practically unattainable through traditional methods. As passive and continuous data sources, Big Data enables the observation of mobility patterns with high spatial and temporal resolution, as well as the identification of previously invisible behaviours, such non-routine trips (Willumsen, 2021).

Nevertheless, the literature has also identified important limitations. As noted by Willumsen (2021), information derived from Big Data sources should not be confined to the measurement of isolated events, as such data may reflect structural biases and partial representations of mobility patterns. Instead, it requires processes of validation, interpretation, and calibration, together with expert judgement and institutional mediation, in order to be meaningfully integrated into planning practice.

Recent debates on smart mobility and digital urban governance have expanded this discussion by examining how digital mobility datasets, sensors, and algorithmic analytics are reshaping the ways mobility systems are observed, governed, and optimized (Docherty, Marsden & Anable, 2018; Kitchin, 2021). While these technologies enable unprecedented analytical capacity, scholars have also raised concerns regarding issues of data justice, representation, and algorithmic bias in mobility systems (Dencik et al., 2019; Leszczynski, 2020). Because digital mobility data often reflects uneven access to digital technologies, the patterns it reveals may privilege digitally connected populations while underrepresenting more vulnerable groups. Consequently, contemporary planning scholarship emphasizes the need to complement data-driven analysis with contextual interpretation, institutional mediation, and participatory processes in order to ensure more equitable and socially grounded mobility planning outcomes.

In parallel, tools based on artificial intelligence have begun to be incorporated into mobility planning, primarily to support the analysis of large datasets, the identification of patterns, and the exploration of alternative scenarios (Da et al., 2025). These tools intensify the need for robust methodological and governance frameworks capable of interpreting and contextualising their outputs.

This article adopts a conception of infrastructure as a relational structure embedded within social arrangements, technologies, and conventions of practice. Infrastructure operates largely in an invisible manner, enabling other systems and activities (Star, 1999). From this standpoint, the tools provided by new information technologies can be understood as a form of infrastructure for mobility planning, insofar as they shape how data is mobilised within decision-making practices. Following Latour's (2005) concept of mediation, technical systems should be understood not as neutral intermediaries but as mediators that actively transform, condition, and reconfigure action, thereby exercising a form of non-human agency.

Because these technological infrastructures mediate rather than merely transmit information, their use in planning cannot be considered sufficient in isolation. Given that planning is a deliberative rather than merely consultative process, participatory approaches have emphasised participation as a central mechanism for knowledge production and decision-making. From the perspective of collaborative rationality, participatory processes seek to generate shared information, foster informed deliberation, and promote collective learning among actors with diverse forms of knowledge and experience (Healey, 1997; Innes & Booher, 2010). Within this framework, participatory workshops are conceived as methodological devices for integrating diverse perspectives into mobility planning.

In this regard, the present study adopts the Seven Generations principle as an ethical and epistemological framework of Indigenous origin, rooted in Haudenosaunee/Iroquois traditions. This principle holds that decisions should be evaluated by considering their effects on seven future generations, as well as the experiences and knowledge of past generations (Lyons, 1980). Through this lens, planning incorporates multiple temporalities and extends its horizon of responsibility beyond the short term, aligning with the concept of intergenerational justice articulated in contemporary scholarship (Weiss, 1989).

Within this context, the concept of mediating infrastructures is introduced in this study to describe the socio-technical arrangements through which heterogeneous forms of knowledge are articulated within planning processes. While existing literature has examined data infrastructures primarily as analytical tools or governance technologies, this research conceptualizes them as mediators that connect technical datasets, institutional decision-making structures, and situated forms of local knowledge. Mediating infrastructures emphasize the relational processes through which data is interpreted, validated, and translated into planning actions.

3 Case study and methodology

The Lake Chapala region, located in the state of Jalisco in central–western Mexico, constitutes a functionally interconnected territorial system composed of multiple municipalities across the states of Jalisco and Michoacán. The study area examined in this paper comprises the municipalities of Chapala, Jamay, Jocotepec, Ocotlán, Poncitlán, Tizapán el Alto, and Tuxcueca. Collectively, the region has an approximate population of 341,564 inhabitants (INEGI, 2020) distributed across intermediate urban centers and rural settlements articulated by regional road corridors (Fig. 2)..

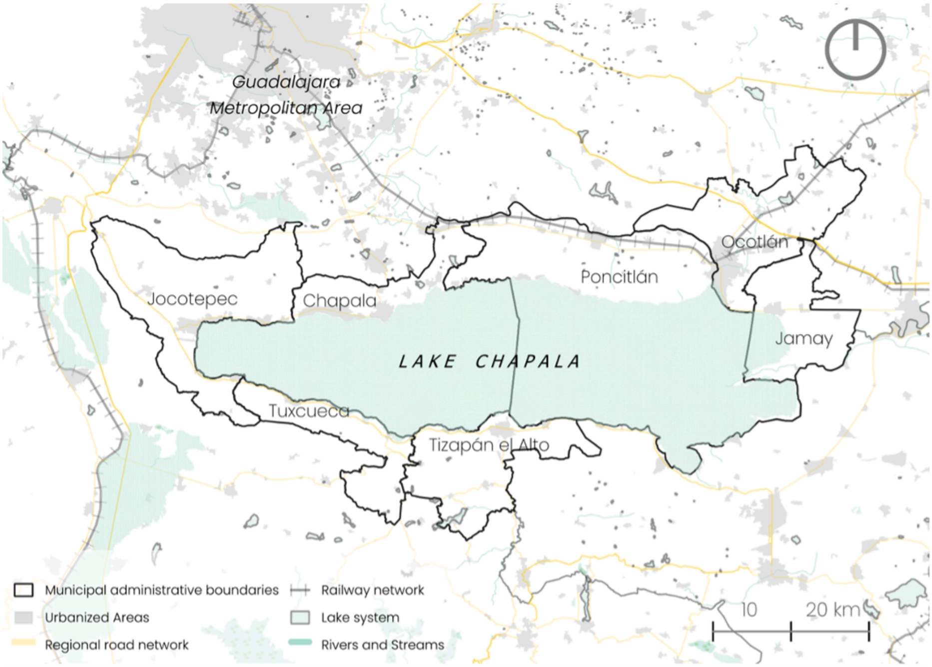

Fig. 2. Municipalities included within the study area of the Lake Chapala region
(Source: Authors' own elaboration, 2026)

Although administratively fragmented, the region operates through shared economic corridors and daily mobility flows that exceed municipal boundaries. Its proximity and functional relationship with the Guadalajara Metropolitan Area (GMA) reinforces this interdependence, particularly through commuting trips, educational travel, and access to specialized services. These dynamics configure the region as a territory where mobility patterns display both local and intermunicipal characteristics.

Beyond its spatial diversity, the region also presents a strong functional specialization among municipalities that shapes everyday mobility patterns and territorial interactions. Industrial activity concentrated in the Ocotlán–Poncitlán corridor has historically positioned this area as one of the main employment nodes within the region, particularly through furniture manufacturing, agro-industrial activities, and logistics associated with regional supply chains. In contrast, lakeshore municipalities such as Chapala and Jocotepec have experienced increasing orientation toward tourism, second-home development, and services linked to recreational and residential activities around Lake Chapala. This differentiated economic geography generates directional commuting patterns in which workers, students, and service users move daily between municipalities according to the distribution of employment centers, educational institutions, and specialized services.

The regional road network plays a central role in articulating these interactions. Corridors connecting Ocotlán, Jamay, and Poncitlán function as key logistical routes supporting both regional commuting and freight circulation associated with industrial production. At the same time, the western lakeshore corridor linking Chapala and Jocotepec connects the region to the Guadalajara Metropolitan Area, facilitating longer-distance commuting and tourism-related travel. These corridors structure the spatial organization of mobility, concentrating traffic flows and shaping accessibility patterns across municipalities. As a result, the region operates less as a set of isolated localities and more as a territorially integrated mobility system in which daily activities depend on intermunicipal connectivity.

From the standpoint of the impacts associated with the current mobility system, recent studies estimate that more than one million tonnes of CO_2 are emitted annually in the Chapala region, linking vehicle-oriented mobility to greenhouse-gas emissions with significant health and environmental consequences (AIPROMADES Lago de Chapala, 2025). The same diagnostic highlights additional externalities, including noise pollution, ecosystem fragmentation driven by transport infrastructure, and the inefficient allocation of urban public space when urban design is dominated by private automobiles (AIPROMADES Lago de Chapala, 2025). In a territory where the lake and surrounding landscape underpin both local identity and tourism-related activity, these externalities are not peripheral: they shape the long-term sustainability of the territorial system, constrain the feasibility of low-carbon mobility options, and reframe transport demand management as an environmental strategy rather than solely a congestion-management strategy (AIPROMADES Lago de Chapala, 2025).

The presence of the lake ecosystem, agricultural landscapes, and environmentally fragile areas means that transport infrastructure and mobility patterns interact directly with ecological systems. Consequently, mobility planning in the region must consider the preservation of the lake's environmental quality and surrounding ecosystems. This dual condition (economic interdependence combined with environmental vulnerability) positions the Lake Chapala region as a particularly relevant case for analyzing regional mobility dynamics within intermediate territories connected to larger metropolitan systems.

3.1 Comprehensive Mobility and Logistics Plan for the Lake Chapala Region (PIMLRC)

The plan emerged from an October 2023 agreement between SEMADET and the European Union under the EUROCLIMA program to reduce motorized transport emissions in the region. The EU appointed AECID as the financial implementing agency, while SEMADET assigned territorial coordination to AIPROMADES, an intermunicipal public organization established in 2010 by the municipalities of the Lake Chapala basin to strengthen regional environmental governance, sustainability policies, and integrated territorial planning (AIPROMADES, n.d.).

The development of the PIMLRC responded to the recognition that mobility dynamics in the Lake Chapala region operate at a scale that exceeds municipal jurisdictions. Daily commuting, educational travel, and freight circulation routinely connect settlements across the lakeshore and industrial corridors, generating mobility patterns that cannot be adequately addressed through isolated municipal planning instruments. In this context, the regional mobility plan sought to establish a shared analytical framework capable of identifying common mobility challenges while respecting the territorial diversity of each municipality.

The methodological design of the PIMLRC also reflected the need to integrate diverse sources of information in order to understand mobility in a territorially complex region. Rather than relying on a single data source or analytical technique, the planning process combined large-scale mobility data, traditional survey-based approaches, and participatory workshops with local communities. This methodological approach allowed the project to capture both structural mobility patterns and lived experiences of mobility, generating a more comprehensive understanding of how residents move within and across the region. As discussed in the following sections, this integration of heterogeneous methods proved central to the construction of mediating infrastructures capable of translating complex mobility dynamics into coordinated regional planning strategies.

The process resulted in a regional portfolio of strategic mobility projects and specific action portfolios for each of the seven participating municipalities. This article examines the findings of the different methodological approaches and analyzes how their integration enabled the construction of mediating infrastructures for regional mobility planning, focusing on three complementary components:

Big Data and Artificial Intelligence Analysis. Mobility data were collected from anonymized mobile devices and connected vehicles, enabling the estimation of travel patterns, origin–destination matrices, travel times, and intermunicipal mobility dynamics. The dataset was obtained from Dat'sWhy comprising 561,981 mobility records derived from 100,025 devices during a 30-day observation period (June 2024).

Following initial acquisition, a filtering process refined the dataset by excluding short-distance movements used only to identify origin–destination clusters and records affected by GPS interruptions that fragmented trips. Adjustments also addressed anonymization processes that periodically update device identifiers. After cleaning, the dataset included 232,921 validated trips from 8,652 devices. Source data consisted of anonymized GPS positions reporting coordinates, timestamps, identifiers, and speeds at roughly 2.5-minute intervals, enabling trajectory reconstruction and segment-level flow analysis by direction. Big Data techniques identified recurrent travel patterns, peak-hour dynamics, and intermunicipal corridors, supporting origin–destination matrices. Traffic volumes were estimated using traffic-stream models relating speed to flow, incorporating behavioral parameters such as driver response time and driving aggressiveness.

To ensure analytical robustness, the Big Data estimations were complemented with on-the-ground traffic observations. These datasets were calibrated through 65 vehicular and pedestrian traffic counts conducted using GoodVision®, an AI-based automated video analytics software. Temporary cameras installed at strategic locations captured traffic flows along primary corridors, intersections, and key mobility nodes throughout the region during the period October–November 2024, recording a total of 3,625 minutes of footage (approximately 60.4 hours).

The recorded footage was processed by the GoodVision® platform using computer vision algorithms capable of detecting, classifying, and quantifying different mobility actors, including passenger vehicles, freight vehicles, motorcycles, buses, cyclists, and pedestrians. The system also generated hourly traffic volumes and directional flow counts, enabling the construction of detailed traffic profiles for each monitoring location.

The resulting information was used to validate and adjust Big Data-derived estimations through calibration factors that aligned observed traffic counts with the aggregated mobility patterns detected in the mobile-device dataset. This calibration process was fundamental for reducing potential representation biases associated with uneven smartphone penetration, device sampling limitations, or spatial coverage gaps. By integrating observed traffic data with large-scale mobility datasets, the methodology improved the reliability of regional mobility estimations and strengthened the analytical basis for subsequent planning scenarios.

Surveys and Sectoral Data Collection. A total of 2,102 origin–destination (OD) surveys were conducted across the seven municipalities, allowing the characterization of trip purposes, frequency, transport modes, and perceived conditions. Additionally, 160 surveys were administered to freight transport operators and logistics stakeholders, covering routes, cargo types, operational times, and sector-specific challenges. This component incorporated the logistics dimension, often underrepresented in passenger-focused mobility studies.

The OD surveys were conducted through in-person household interviews carried out directly at residents' homes across the seven municipalities included in the study area: Chapala, Jamay, Jocotepec, Ocotlán, Poncitlán, Tizapán el Alto, and Tuxcueca. Survey teams followed a structured sampling design in which the number of interviews conducted in each municipality was proportional to its population size according to the most recent demographic data available. This proportional sampling strategy ensured statistical representativeness across the region and allowed mobility patterns to be analyzed while accounting for differences in municipal population size and urban structure.

Fieldwork was carried out during a two-week period in November 2024 by trained survey teams who followed standardized questionnaires and protocols to ensure data consistency and reliability. Respondents were asked to report information on their most recent trips, including origin and destination locations, travel purposes, departure times, transport modes, and perceived mobility constraints. The surveys were conducted and digitally recorded using a mobile data-collection platform Epicollect, which allowed enumerators to register responses directly in the field through handheld devices. This system facilitated georeferenced data capture, reduced transcription errors, and enabled the real-time monitoring and validation of survey entries during the fieldwork process.

In addition to trip-level data, the surveys collected basic socio-demographic information that allowed mobility behavior to be interpreted in relation to household characteristics, employment conditions, and access to transport options. Together, the household surveys and freight-sector interviews provided a detailed picture of both passenger mobility and logistics dynamics, complementing the structural patterns identified through Big Data analysis.

Participatory Workshops. Four participatory workshops were conducted under the "Seven Generations" approach, which promotes intergenerational deliberation to incorporate long-term perspectives into territorial decision-making. The approach is grounded in the principle that present decisions should consider impacts on future generations, fostering dialogue among actors from different ages, sectors, and institutional scales. For implementation, seven participants representing distinct generational cohorts were invited to structure deliberative discussions.

The workshops were held in Jamay, Tizapán el Alto, Ocotlán and Chapala enabling participation from residents and stakeholders representing different municipalities and territorial contexts within the basin. This distributed format helped ensure that discussions incorporated perspectives from both lakeshore communities and inland municipalities, reflecting the territorial diversity of the region.

The workshop design explicitly sought the participation of representatives from seven generational groups in order to reflect a wide temporal spectrum of experiences and expectations regarding mobility in the region. Participants were selected to represent seven generational cohorts based on life-cycle stages: childhood (0–14), adolescence (15–19), young adulthood (20–29), early adulthood (30–44), mature adulthood (45–59), early seniority (60–74), and advanced age (75+).

The workshops were also designed to capture the dimension of lived space, that is, the everyday experiences through which residents interact with mobility systems in their daily routines. Rather than focusing exclusively on technical indicators, participants were invited to discuss their daily travel practices, perceived barriers to accessibility, safety concerns, and the social meaning of mobility in their communities. This perspective allowed the workshops to reveal qualitative insights regarding how mobility infrastructures are experienced and interpreted within the territorial context of the Lake Chapala region.

To analyze the discussions generated during the workshops, the research team employed Cortico, a conversation analysis platform designed to identify recurring themes and patterns in large sets of recorded dialogue. Cortico processes transcribed conversations using natural language processing techniques to detect clusters of related ideas, frequently mentioned concepts, and thematic relationships among participants' statements. Through this process, the platform helps transform qualitative conversations into structured insights by highlighting the most prominent discussion topics and mapping how they relate to one another.

Data integration. Beyond the individual methodological components described above, the research incorporated a specific integration stage aimed at translating heterogeneous datasets into planning decisions. Rather than producing additional data, this stage established a structured analytical process through which the results generated by different methods could be compared, interpreted collectively, and ultimately synthesized into planning priorities (Fig. 3).

The integration process followed three main analytical operations: comparison, validation, and synthesis. First, the outputs derived from the different datasets were systematically compared in order to identify convergences and divergences across analytical results. This comparison made it possible to detect recurring mobility dynamics that appeared consistently across multiple sources of evidence, strengthening the reliability of the identified patterns.

Second, these patterns were subjected to a validation process through contextual interpretation. Technical findings were examined in relation to territorial conditions, local mobility challenges, and broader socio-environmental dynamics affecting the region. This step allowed the research team to assess the relevance of the analytical results and to refine their interpretation within the specific territorial context.

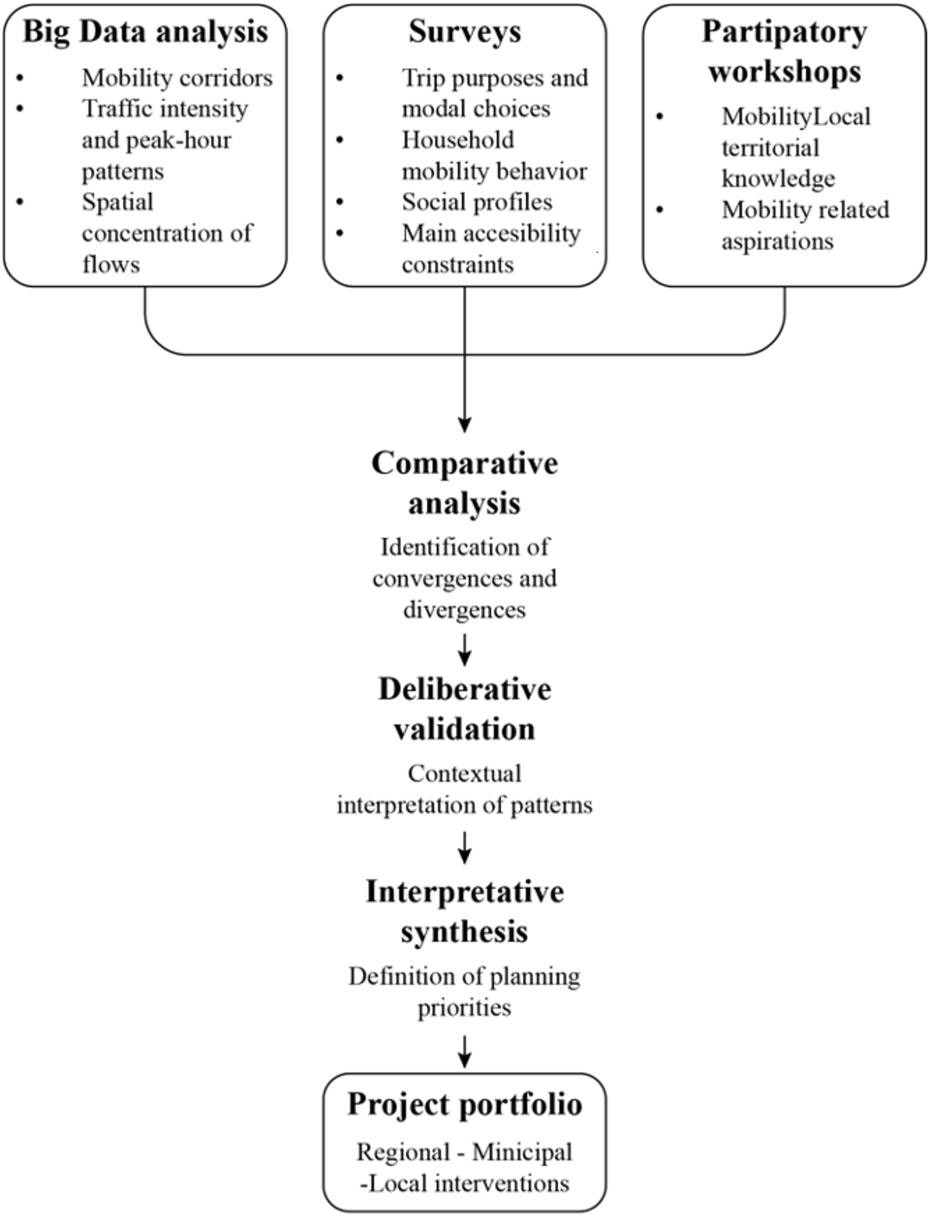

Fig. 3. Analytical integration process for decision making
(Source: Authors' own elaboration, 2026)

Finally, the validated findings were translated into planning priorities through an interpretative synthesis. This stage connected regional mobility structures with localized accessibility needs, enabling heterogeneous datasets to function as complementary sources of evidence within the decision-making process and informing the definition of the regional project portfolio.

3.2 Analytical approach

The paper presents findings corresponding to each methodological component and subsequently develops an integrative discussion. Its objective is to examine how data-driven tools, traditional survey instruments, and participatory methodologies contributed to the formulation of the regional project portfolio for the Lake Chapala region. In doing so, the article identifies the specific contributions, limitations, and complementarities of each approach, analyzing how their articulation supported the construction of mobility proposals and enabled technical systems to operate as mediating infrastructures, consistent with the theoretical framework outlined earlier.

4 Integrated findings

This section presents the integrated findings derived from the combined application of Big Data analysis, AI-based traffic counts, origin–destination surveys, logistics surveys, and participatory workshops conducted across the Lake Chapala region. Rather than reporting the results of each methodological component in isolation, the analysis focuses on patterns that emerged through their cross-validation and interaction. The following subsections describe these empirical findings and their implications for the configuration of the regional mobility project portfolio.

4.1 Regional Mobility Patterns

The integrated analysis identified mobility flows across seven municipalities structured around four primary corridors. These corridors reflect distinct economic and functional roles within the regional system, ranging from industrial logistics and intermunicipal commuting to tourism and agricultural mobility.

Traffic volumes and operational conditions vary significantly across corridors. The Industrial–Logistics corridor (Poncitlán–Ocotlán–Jamay) concentrates the highest traffic intensity and operates under oversaturated conditions (LOS F), largely associated with freight activity and industrial logistics. The Urban–Tourism corridor (Chapala–Ajijic–Jocotepec) supports both local mobility and tourism flows, experiencing high-density conditions during weekends and seasonal peaks (LOS D). In contrast, the Agricultural corridor (Jocotepec–Tuxcueca–Tizapán el Alto) reflects mixed productive and commuting dynamics, operating near capacity in several segments (LOS D–E). The Ecotourism–Fishing corridor (San Juan Tecomatlán–Mezcala) registers lower volumes but exhibits strong seasonal variability associated with tourism and local economic activity (Table 1).

Temporal analysis revealed differentiated peak periods associated with work commuting, tourism activity, and school-related travel, producing localized congestion in segments such as Ocotlán–Jamay and Jocotepec–Tuxcueca.

The analysis also highlights the continued relevance of lacustrine mobility within the regional system (Fig.4). Lakeside transport routes support tourism connections to Isla de los Alacranes and Isla de Mezcala, while small-scale fishing routes operate across nearshore areas as part of local productive practices.

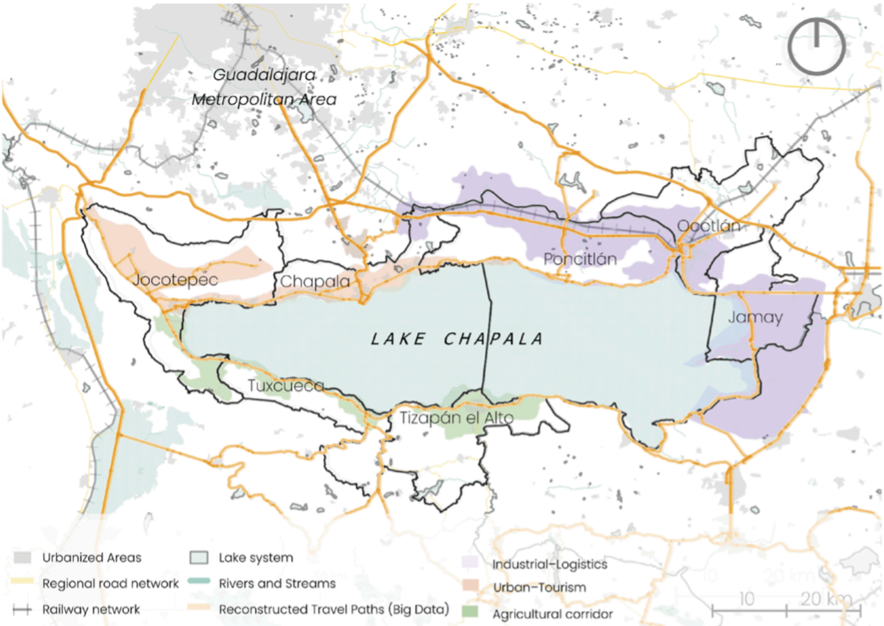

Fig. 4. Territorial Structure of Regional Mobility: Corridors, Flows, and Saturation Levels
(Source: Authors' own elaboration, 2026)

Table 1. Territorial Structure of Regional Mobility: Corridors, Flows, and Saturation Levels

Corridor	Segments	Daily vehicles	Saturation level
Industrial -logistic	Poncitlán-Ocotlán-Jamay	22,500	F
Urban-to uristic	Chapala-Ajijic-Jocotepec	9,500	D
Agricultu ral	Jocotepec-Tuxcueca-Tizapán	10,500	E,D

4.2 Survey Findings: Mobility Patterns and Municipal Differentiation

A total of 2,102 origin–destination surveys were conducted across the seven municipalities of the Lake Chapala region. The sample shows a slight female predominance (52%), concentrated mainly in the 40–59 age cohort.

At the regional scale, mobility is dominated by walking, private vehicles, and public transport. However, important municipal variations reflect differences in urban form and local economic structures. Walking is more prevalent in compact settlements, while higher private vehicle use is associated with municipalities exhibiting stronger residential expansion and intermunicipal commuting dynamics. In contrast, motorcycle use is more pronounced in municipalities characterized by industrial employment and medium-distance daily travel.

Trip purposes are primarily related to employment, education, and healthcare. These patterns reflect the uneven spatial distribution of economic activities and strategic services across the region, with certain municipalities functioning as employment centers while others concentrate educational or service-related trips.

Qualitative responses highlight recurring structural challenges in the regional mobility system. Public transport deficiencies were consistently reported, including irregular service frequencies, limited route coverage, and high fares. Additionally, the increasing presence of motorized two-wheelers emerged as a recurring concern due to safety risks, noise pollution, and underage operation.

These findings indicate that, while regional mobility patterns share common structural characteristics, municipal differences in urban form, economic specialization, and service distribution produce differentiated mobility experiences across the Lake Chapala region.

4.3 Participatory Reframing of Technical Priorities

The intergenerational workshops provided a qualitative layer that expanded the temporal scope of mobility analysis across the Lake Chapala region. Participants reconstructed territorial memory associated with productive activities, water use, and everyday mobility practices, identifying long-term transformations affecting both environmental conditions and community life. Older generations recalled lacustrine transport connecting lakeside settlements, agricultural routes linked to local production, and recreational uses of rivers and the lake that have largely disappeared with urban expansion.

Environmental deterioration emerged as a recurrent theme. Participants associated the decline in water quality, biodiversity loss, and reduced recreational use with agrochemical runoff, wastewater discharge, monoculture expansion, and industrial activity. These processes were described as contributing to the gradual weakening of the cultural and functional relationship between communities and the lake.

Historical trajectories associated with productive activities such as agriculture and fishing were frequently mentioned, alongside transformations driven by the expansion of motorized mobility, industrial development, and changes in hydrological patterns linked to urban growth. Participants recalled the historical use of lacustrine transport connecting lakeside communities, which once reduced travel distances and facilitated social interaction between settlements. Today, these connections have largely disappeared, and mobility depends predominantly on road-based transport systems. The growth of private vehicles and motorcycles was frequently mentioned as contributing to increased road safety concerns, and a general perception of accelerated and more stressful daily routines.

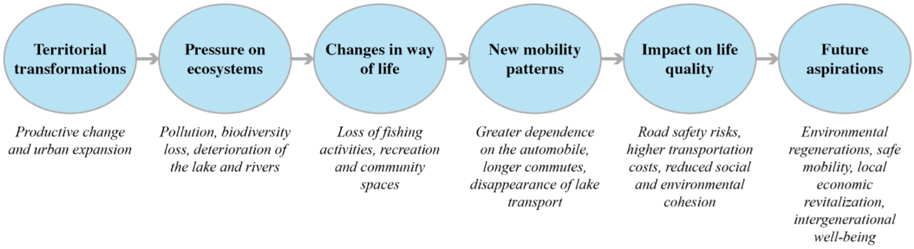

Fig. 5. Sequence of territorial transformations and mobility changes identified in intergenerational workshops.
(Source: Authors' own elaboration, 2026)

Across workshops, a consistent narrative sequence became visible: territorial transformation leading to ecosystem pressure, shifts in livelihoods and communal spaces, increased dependence on motorized road transport, and subsequent impacts on quality of life. As summarized in Fig. 5. This progression reflects how mobility changes are embedded within broader socio-environmental dynamics.

Finally, the workshops highlighted community aspirations for the future. Participants expressed a shared desire to restore environmental quality in the lake and rivers, strengthen environmental awareness, improve urban infrastructure and road safety, expand tree cover, recover recreational spaces associated with water bodies, and create better local employment and educational opportunities. Many participants also emphasized the importance of strengthening regional public transport systems and exploring alternative mobility options, including the potential reconsideration of lacustrine transport, as part of a broader vision linking mobility planning with environmental recovery and community well-being.

Finally, analysis brings Big Data, AI-assisted traffic counts, surveys, fieldwork, and participatory workshops together around cross-cutting mobility problems: the mismatch between regional flows and local accessibility, the coexistence of tourism, freight, and everyday mobility pressures, the seasonal intensification of congestion, and the institutional fragmentation that limits coordinated responses.

This integrated reading shows that no single method was sufficient to explain the observed mobility dynamics. Big Data helped identify regional movement patterns and intermunicipal connections, but it could not fully explain the social meaning, purpose, or perceived barriers behind those movements. AI-assisted counts provided detailed evidence of modal composition and traffic intensity at specific points but required field interpretation to understand local bottlenecks and conflicts. Surveys added information on travel behavior, user experience, and mobility needs, while participatory workshops helped contextualize these findings through local knowledge and institutional perspectives. The analytical value of the methodology therefore lies in the way these sources were brought into dialogue to construct a more complete diagnosis.

4.4 Configuration of the Project Portfolio

The configuration of the project portfolio reflects the multiscalar mobility dynamics identified through the integrated findings. Rather than concentrating interventions at a single scale, the portfolio was structured across regional, municipal, and local levels in response to differentiated patterns of intermunicipal flows, localized constraints, and community priorities. The complete list of projects is summarized in Appendix 1.

At the regional scale, the portfolio includes corridor-oriented interventions focused on road conservation and freight management, responding to the concentration of intermunicipal commuting and logistics flows identified in the mobility analysis.

At the municipal scale, strategic road system packages were defined for each municipality, addressing infrastructure deterioration and connectivity gaps while reinforcing the role of key municipalities as subregional mobility nodes.

At the local scale, a set of accessibility and environmental interventions was proposed, including passenger nodes, pedestrian improvements, lacustrine mobility infrastructure, and wildlife crossings. These projects respond primarily to accessibility deficits identified in surveys and to priorities emerging from participatory workshops, particularly those related to pedestrian safety, environmental restoration, and the reconsideration of lakeside mobility alternatives.

Together, the portfolio integrates structural connectivity improvements with localized and community-informed interventions across the regional mobility system.

5. Discussion

This case demonstrates that neither traditional survey-based methods nor data-driven approaches are sufficient on their own to support regional mobility planning. Each methodological infrastructure operates within specific epistemic boundaries, generating distinct forms of knowledge while simultaneously excluding others.

The Big Data component offered broad spatial and temporal coverage, enabling the identification of intermunicipal flows and structural mobility corridors across the region. However, in the specific case of Lake Chapala, its limitations were primarily structural rather than spatial. Because the mobile datasets were anonymized and device-based, they did not include sociodemographic attributes such as gender, age, income level, trip purpose, or transport mode. While ethically necessary, this anonymity restricted interpretation to volumetric and spatial dimensions of movement. Moreover, reliance on mobile phone activity may have underrepresented segments of the population with limited access to digital services, potentially biasing observed patterns toward digitally connected users.

Origin–destination and freight surveys provided behavioral depth despite covering less than 2% of the population at a given time. Through direct interaction with travelers and operators, they captured trip purposes, safety perceptions, socioeconomic characteristics, and constraints related to age, gender, employment, and household conditions. However, their limited sample size and short temporal scope restricted their capacity to represent the structural scale and continuity of intermunicipal mobility patterns. Operational challenges (including respondent fatigue, distrust, simplified responses, and underreporting) also affected data quality, particularly within a fragmented and multimodal regional mobility context.

It is precisely within these reciprocal limitations that methodological complementariness becomes critical. Survey data functioned as a form of analytical "de-anonymization", not at the individual level, but at the interpretative level; reintroducing behavioral and demographic attributes that contextualized aggregate mobility flows. Through cross-referencing, anonymous digital traces were embedded within social structures, reducing blind spots and expanding explanatory capacity. In this sense, surveys did not merely validate Big Data outputs; they enabled their social interpretation.

From the perspective of mediating infrastructures, the relevance of this methodological articulation lies in the way these sources reorganize relationships between knowledge, institutions, and territorial decision-making. In this case, Big Data, AI-assisted counts, surveys, fieldwork, and participatory workshops formed an intermediary system through which otherwise fragmented forms of evidence could be translated, compared, and negotiated.

This mediation occurred in at least three dimensions. First, it was epistemic: digital traces made regional mobility structures visible, while surveys and workshops reintroduced social attributes, lived experience, and territorial meaning into the interpretation of those patterns. Second, it was institutional: the integrated evidence base created a common diagnostic language across municipalities with different capacities, priorities, and administrative boundaries. Third, it was territorial: the methodological system connected regional mobility flows with local accessibility problems, environmental pressures, and community perceptions that would have remained disconnected if analyzed through a single method.

Understanding the planning process as a mediating infrastructure therefore shifts the interpretation of data-driven mobility planning from a question of technical optimization to one of translation and coordination. The value of data-driven tools reside in their ability to become part of a broader socio-technical arrangement that structured dialogue, exposed blind spots, and enabled shared problem definition. In fragmented non-metropolitan regions such as Lake Chapala, this mediating role is particularly important because mobility problems exceed municipal boundaries while planning authority remains institutionally dispersed.

The incorporation of fieldwork and intergenerational workshops revealed additional layers of mobility complexity. Participatory processes surfaced in informal routes, micro-infrastructures, safety perceptions, and community conflicts that were not visible in digital traces or aggregated datasets. The “Seven Generations” framework introduced temporal depth, contrasting historical lacustrine mobility and diversified local economies with contemporary motorized dependence and environmental degradation.

Despite the valuable insights generated, the intergenerational workshops faced several practical limitations. A key challenge was ensuring participation from representatives of the seven generational cohorts proposed by the methodology, which required extensive coordination and community outreach. Uneven institutional support across municipalities and the limited project timeframe further constrained implementation. Although workshops were originally planned in all seven municipalities of the Lake Chapala region, they were ultimately conducted in four.

Beyond the specific findings of the Lake Chapala case, the results offer broader insights for the role of data-driven mobility planning in non-metropolitan regions. Much of the literature on data-driven urbanism and smart mobility has been developed in large metropolitan contexts where dense digital infrastructures and strong institutional capacities facilitate the implementation of advanced analytical tools.

The experience of the Lake Chapala region suggests that in territorially fragmented and institutionally uneven regions, the value of data-driven approaches lies less in technological sophistication and more in their capacity to structure coordination and shared understanding among multiple jurisdictions. The case demonstrates that data infrastructures require interpretative mediation, institutional collaboration, and participatory engagement in order to become meaningful planning instruments. Their contribution through the perspective of mediating infrastructures lies in producing the conditions for collective interpretation. In this sense, data-driven planning becomes meaningful when it mediates between structural mobility evidence, situated territorial experience, and the institutional processes through which decisions are made.

5 Conclusions

The strength of regional mobility planning is the articulation of heterogeneous methods whose complementariness enhances interpretative and decision-making capacity. Big Data provided structural visibility, revealing intermunicipal corridors, commuting intensities, and freight dynamics through patterns of revealed preference. Surveys and participatory workshops, in turn, contributed declared preferences, behavioral interpretation, territorial memory, and normative orientation.

At the same time, the implementation of such integrative approaches is not without constraints. Budgetary limitations, institutional capacity, political cycles, and the willingness of both authorities and residents to participate can restrict the simultaneous deployment of multiple methods. Achieving methodological complementariness therefore requires not only technical coordination, but also governance commitment, transparency in data processing, and sustained intermunicipal collaboration.

This case also underscores the importance of understanding mobility as part of a broader socio-environmental territorial system rather than merely a transport problem. Throughout the participatory and diagnostic processes, mobility transformations were consistently linked to environmental degradation, shifts in productive activities, and changing relationships between communities and the lake ecosystem. The decline of lacustrine mobility, the expansion of road-based transport, and the intensification of agricultural and industrial practices illustrate how mobility patterns are embedded within long-term ecological and economic transformations. In this sense, regional mobility planning cannot be conceived solely in terms of infrastructure provision or traffic management. Instead, it requires recognizing how mobility interacts with water systems, land use, environmental quality, and local livelihoods. Addressing mobility challenges in territories such as the Lake Chapala basin therefore demands planning frameworks capable of integrating transport policies with environmental restoration, territorial governance, and regional development strategies. The value of mediation lies precisely in its capacity to integrate these different forms of knowledge into a coherent interpretative framework that informs decision-making. By enabling dialogue between data-driven analysis, lived experience, and governance institutions, mediating infrastructures transform fragmented information into actionable territorial understanding.

Ultimately, the Lake Chapala experience illustrates that data abundance alone does not guarantee better planning outcomes. Rather, it is the capacity to mediate across scales, knowledge systems, and institutional boundaries that strengthens territorial governance, enhances legitimacy, and supports more equitable and environmentally sustainable regional mobility strategies, offering a transferable framework for other non-metropolitan regions facing similar challenges of territorial fragmentation, environmental pressure, and intermunicipal mobility integration

Appendix 1.

Multiscalar project portfolio (AIPROMADES Lago de Chapala - Urbanística, México, 2026).

Scale	Intervention Type	Number	Linked integrated findings
Regional	Road conservation and maintenance corridors	13	Regional mobility corridors; intermunicipal commuting flows

			(Big Data and survey findings)
	Intermunicipal freight management zones	4	Logistics surveys; freight concentration patterns (Big Data and survey findings)
Subtotal Regional		17	
Municipal	Strategic Road System (SVE) packages	7	Reported infrastructure gaps; municipal differentiation in survey data (survey findings)
	Municipal bus terminals (Ocotlán, Poncitlán)	2	Identified subregional centralities; passenger flow concentration (Big Data and survey findings)
Subtotal Municipal		9	
Local	Passenger nodes	73	Transfer needs identified in OD surveys (survey findings)
	Lacustrine nodes	35	Participatory reframing; lake reconnection narratives (intergenerational workshops)
	Last-mile logistics nodes	8	Sectoral freight surveys (survey findings)
	Parking polygons	9	Congestion and modal split patterns (Big Data findings)
	Equipped and upgraded bus stops	21	Public transport deficiencies (survey findings)
	Accessibility stairways	16	Accessibility constraints (survey findings)
	Pedestrian/cyclist tunnels	8	Road safety concerns (survey findings and intergenerational workshops)
	Overpasses	16	Traffic conflict points (Big Data and survey findings)

	Wildlife crossings	13	Environmental pressures and territorial fragmentation concerns (intergenerational workshops)
	Dry dikes (littoral)	3	Environmental deterioration and lakeshore protection narratives (intergenerational workshops)
Subtotal Local		202	
Total Portfolio		228	Multiscale response to integrated findings

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References

1. AIPROMADES Lago de Chapala. (2025, June 17). Movernos mejor también es cuidar el entorno. AIPROMADES. https://www.aipromades.org/movernos-mejor-tambien-es-cuidar-el-entorno/
2. AIPROMADES Lago de Chapala & Urbanística. (2026). Plan Integral de Movilidad de la Región Lago de Chapala (PIMLRC) [Unpublished technical report].
3. Asociación Intermunicipal para la Protección del Medio Ambiente y Desarrollo Sustentable del Lago de Chapala (AIPROMADES). (n. d.). Quiénes somos. https://www.aipromades.org/quienes-somos/
4. Da, X., Zhang, Y., Li, S., & Wang, J. (2025). Artificial intelligence applications in transport planning: Data analytics, modelling, and scenario exploration. Transportation Research Part C: Emerging Technologies, 162, 104605. https://doi.org/10.1016/j.trc.2024.104605
5. Dencik, L., Hintz, A., Redden, J., & Treré, E. (2019). Exploring data justice: Conceptions, applications and directions. Information, Communication & Society, 22(7), 873–881. https://doi.org/10.1080/1369118X.2019.1606268

6. Docherty, I., Marsden, G., & Anable, J. (2018). The governance of smart mobility. Transportation Research Part A: Policy and Practice, 115, 114–125. https://doi.org/10.1016/j.tra.2017.09.012
7. Healey, P. (1997). Collaborative planning: Shaping places in fragmented societies. Macmillan.
8. Instituto Nacional de Estadística y Geografía (INEGI). (2020). Censo de Población y Vivienda 2020. https://www.inegi.org.mx/programas/ccpv/2020/
9. Innes, J. E., & Booher, D. E. (2010). Planning with complexity: An introduction to collaborative rationality for public policy. Routledge.
10. Kitchin, R. (2014). The real-time city? Big data and smart urbanism. GeoJournal, 79(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8
11. Kitchin, R. (2021). The data revolution: A critical analysis of big data, open data and data infrastructures in urban governance. London: Sage.
12. Latour, B. (2005). Reassembling the social: An introduction to actor-network-theory. Oxford University Press.
13. Leszczynski, A. (2020). Digital methods II: Data visualization, digital geographies, and the politics of knowing. Progress in Human Geography, 44(3), 540–551. https://doi.org/10.1177/0309132519836636
14. Lyons, O. (1980). An Iroquois perspective. In E. Grinde & B. Johansen (Eds.), Exemplar of liberty: Native America and the evolution of democracy (pp. 29–38). UCLA American Indian Studies Center.
15. Ortúzar, J. de D., & Willumsen, L. G. (2011). Modelling transport (4th ed.). Wiley.
16. Sheller, M. (2018). Mobility justice: The politics of movement in an age of extremes. London: Verso.
17. Star, S. L. (1999). The ethnography of infrastructure. American Behavioral Scientist, 43(3), 377–391. https://doi.org/10.1177/00027649921955326
18. Torre-Bastida, A. I., Del Ser, J., Laña, I., Ilardia, M., Bilbao, M. N., & Campos-Cordobés, S. (2018). Big data for transportation and mobility: Recent advances, trends and challenges. IET Intelligent Transport Systems, 12(8), 742–755. https://doi.org/10.1049/iet-its.2018.5188
19. Weiss, E. B. (1989). In fairness to future generations: International law, common patrimony, and intergenerational equity. United Nations University.
20. Willumsen, L. (2021). Use of Big Data in transport modelling. International Transport Forum Discussion Papers, No. 2021/05. OECD Publishing. https://doi.org/10.1787/9d5f2c54-en