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# Editorial: Data-driven urban dynamics: sustainable urbanization and mobility in peripheral areas

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## Editorial on the Research Topic

**Data-driven urban dynamics: sustainable urbanization and mobility in peripheral areas**

## Introduction

Cities are expanding into their peripheral zones (Gottero et al., 2023) at unprecedented speed, and these edges now host some of the most challenging planning and governance problems. In many cases, these edges are where new development meets long-standing settlements and rural livelihoods. These zones represent critical junctures where the theoretical models of urban systems (Batty, 2013; Bettencourt and West, 2010) are tested against complex, lived realities. This phenomenon is pronounced in transitional zones, where modernity meets tradition, urban and rural landscapes collide, and traditional human life encounters metropolitan and global markets. These zones present unique systemic challenges spanning mobility, transportation (Nuuyandja et al., 2024), economics, culture, and social equity. The rigorous study, exploration, and analysis of these quasi-urban frontiers are thus imperative for achieving sustainable development, offering new insights derived from both global and local similarities and contrasts.

Sustainable responses at these edges require pairing advanced digital tools with deep local knowledge. Geospatial mapping, simulation, mobile applications, and real-time data are essential for revealing patterns and sharpening planning decisions, but they can only achieve impact when embedded in participatory processes that reflect community priorities and cultural practices. In short, technical sophistication, which includes advanced methods for quantifying human behavior and urban experience (Mohareb and Ashraf, 2025), must be matched with social embeddedness (Goubran, 2021). Understanding local dynamics and community initiatives is key to developing truly inclusive and resilient solutions. While technology offers vital tools for optimized transport, better information, and community engagement in planning, success

ultimately depends on integrating these advancements with local knowledge and practices.

This balance is especially prominent in the Global South, where planned urban expansions intersect with organic growth and traditional livelihoods increasingly interact with national and global markets. In these settings, mobility systems are easily overstretched (Swelam et al., 2024), access to services is uneven, tenure and institutional arrangements are complex (Monstadt et al., 2022), and ensuring socio-spatial inclusivity is a constant challenge. Placing data-driven approaches within these lived contexts is therefore not optional; it is the fundamental condition for turning measurement into action and for ensuring that interventions at the edge are both effective and equitable. This fundamental tension between quantitative metrics and qualitative meaning (Cucuzzella and Goubran, 2020) must be addressed.

Three themes orient the call. Community engagement and local knowledge are foregrounded, not as post-hoc consultation but as the basis for designing and evaluating interventions in the urban edge. Spatial analysis is encouraged where it illuminates critical interfaces—such as urban-rural boundaries, transitions from historic to new districts, and other edge conditions in which small siting decisions carry system-wide consequences. The Research Topic also highlights the co-evolution of informal and formal systems: in many peripheries, transport, housing, and dispute resolution depend on hybrid arrangements that standard plans ignore at their peril. Finally, urban planning and mobility dynamics are approached as coupled systems: how new infrastructure ties emerging districts to metropolitan cores will shape both opportunity and vulnerability for decades.

The six articles collected in this Research Topic map show how each contribution responds to this call, both empirically and methodologically. The articles include explorations of institutional capacity and land dispute resolution at the urban edge (Ethiopia), innovative regional population modeling (drawing on Lotka-Volterra and Gravity dynamics), an examination of farmer entrepreneurs' return migration motives for rural development (China), consideration for corridor-scale cultural tourism spillovers (China-Pakistan Economic Corridor), village-level demographic diagnostics and hollowing (Lankao County, China), and an investigation into national low-carbon mobility and carbon productivity (China).

## Key themes and contributions

The papers in this Research Topic can be grouped into three primary areas: spatial modeling, socio-cultural dynamics, and systemic governance challenges.

### Spatial modeling and sustainable mobility

This area highlights the role of data-driven spatial analysis techniques in urban systems, demonstrating how they can be leveraged to study and forecast mobility, environmental efficiency, and population change.

Özdilek presents a unified regional population-forecasting model that couples Lotka–Volterra dynamics with a probabilistic

gravity component. The design captures nonlinear interregional interactions, migration frictions, and size effects. It is calibrated based on Québec's three clusters—Montréal, Québec City, and the rest of the province—and validated for the period 2021–2023. Projections to 2053 reveal a demographic attractor: Québec City experiences marked growth, the rest of Québec experiences modest growth, and Montréal remains broadly stable. This pattern mirrors metropolitan dispersal and matches external cohort benchmarks. The framework complements cohort accounting, yielding interpretable equilibria and trajectories for infrastructure and service planning in edge-growth contexts (Özdilek).

Sun et al. bring the climate transition into the national debate on mobility. They estimate total-factor carbon productivity in transport across 30 Chinese provinces (2007–2022) using a super-efficiency slack-based DEA with undesirable outputs, track spatial dynamics via kernel density and standard-deviational ellipses, and identify drivers with a fixed-effects Spatial Durbin Model and effect decomposition. Productivity rises overall, but disparities sharpen: the east sustains high efficiency, the center and west lag and polarize, spatial dependence intensifies, and the performance centroid shifts southwest. Economic development and industrial upgrading enhance local productivity, while openness primarily works through positive spillovers. Environmental regulation depresses local efficiency in the short run yet benefits neighbors; informatization and consumption are current drags; and government support is statistically insignificant. Policy priorities include the east-to-west diffusion of technology and capital, coupled with services upgrades and intelligent manufacturing, as well as deeper digital and low-carbon integration to prevent lock-in in lagging regions (Sun et al.).

### Socio-cultural dynamics at the urban-rural interface

Feng et al. shift the focus from regional systems to household-level motives. They explore how these motives structure urban–rural ties. Surveying 1,573 “farmer entrepreneurs” in Jintang County, China, the authors model return-to-hometown intentions—an antecedent to reinvesting skills and capital in rural revitalization—using an ordered logit with an ordered probit check. Explanatory domains cover economic agency, family constraints, cultural embeddedness, and policy perceptions. The findings are clear: income has a small positive association; childcare obligations lower the propensity to return; eldercare is not significant; and cultural anchors, such as frequent home visits and a strong hometown identity, increase the tendency to return. General policy awareness is inert, whereas specific expectations about local economic development and education raise intentions. The study highlights the central claim of the issue: data-driven tools must reflect lived contexts and household realities, not just abstract indicators (Feng et al.).

Cheng et al. turn to the village scale, where the costs of peripheral transition surface earliest. In Lankao County, Henan, Cheng et al. build a population hollowing index for 413 villages by combining entropy weights with AHP to integrate three components: out-migration, labor-force outflow, and age structure.

They then apply global and local Moran's I and GeoDetector to map patterns and identify drivers. The spatial picture is clear: a southwest-to-northeast gradient, significant global autocorrelation, and both high-high and low-low clusters. Explanatory power stems from joint effects—service and infrastructure accessibility, the presence of local enterprises, and resource endowments—with pairwise interactions strengthening influence. Policy follows from diagnosis: planned land transfer and scale management, upgrading and diversification of cooperatives and local firms, and reallocation of healthcare and eldercare, all targeted through the spatial diagnostics to reinforce villages where the periphery is fraying and to knit networks where recovery is feasible (Cheng et al.).

## Systems challenges, governance, and economic spillover

Udessä and Adugna (2025) examine the institutional architecture required to make peripheral urbanization fair and effective. They use a mixed-methods design—comprising 391 household questionnaires, 22 key-informant interviews, and two focus groups to identify the recurrent sources of dispute: boundary ambiguities, expropriation based on false evidence, problematic real estate lending, contested use rights, and illegal land sales. They then trace how such conflicts move or stall through the formal system, revealing that city-level judges lack specialized training in land law and that responsibilities across tiers are unclearly delegated; informal dispute-resolution customs remain disconnected from administrative channels. The result is a queue of unresolved cases stretching from first-instance courts to regional high courts. The paper advocates for practical repair by strengthening regional arbitration institutions through training, legal resources, and adequate infrastructure—steps that would lower costs, accelerate resolution, and enhance legitimacy (Udessä and Adugna, 2025).

Zuhaib et al. situate cultural and spatial dynamics within a megaproject. The authors examine how the China-Pakistan Economic Corridor (CPEC) related infrastructure and cultural values interact to shape tourism and how these effects propagate across neighboring districts. Methodologically, the paper integrates cultural mechanisms, modeled using Partial Least Squares-SEM based on Hofstede's dimensions, with a Spatial Durbin Model to estimate both local and spillover effects, supported by Moran's I and LISA diagnostics. Empirically, cultural tourism indicators exhibit stronger clustering within the corridor, and tourism behaves cooperatively within CPEC (gains in one district spill over into neighbors) but competitively outside it (growth in one locale is associated with declines nearby). Power distance, uncertainty avoidance, and individualism generally support tourism; masculinity is weak or context-dependent; and long-term orientation flips from negative outside CPEC to positive—and sizable—inside it, underscoring the payoff to long-horizon planning when anchored in connective infrastructure (Zuhaib et al.).

## Conclusion and future agenda

Across these six articles, three cross-cutting lessons emerge that speak directly to the issue's framing of Spatial Modeling, Socio-Cultural Dynamics, and Systemic Governance.

1. Spatial analysis must be interpretable and decision-oriented. The Québec forecasting framework demonstrates how theory-driven dynamics can be validated on short horizons and then utilized to inform the design of long-horizon services and infrastructure at a metropolitan scale (Özdilek).
2. Community engagement is not a decorative add-on; it is a vital component of effective leadership. The Jintang County study demonstrates that strong place-based identities and concrete policy expectations, not generic awareness, shape behavioral intentions in ways planners can act on (Feng et al.). The Ethiopian dispute-resolution analysis reminds us that legitimacy and capacity in formal institutions are as central to peripheral stability as any physical infrastructure, and that informal practices must be integrated into administrative systems if plans are to be effective (Udessä and Adugna, 2025).
3. Mobility and climate are co-produced systems. CPEC's cooperative spillovers under long-term orientation show how infrastructure and culture interact to diffuse benefits across space (Zuhaib et al.), while the provincial transport study links efficiency, equity, and spillover dynamics to a practical pathway for low-carbon transition without widening regional disparities (Sun et al.).

Collectively, these six articles underscore the core message of this Research Topic: sustainable urbanization in peripheral areas requires the seamless integration of advanced spatial and data-driven methods with a profound understanding of local knowledge, socio-economic factors, and institutional realities. The empirical evidence and methodological innovations presented here offer concrete pathways for urban scientists, planners, and policymakers to navigate the complexities of the urban edge, advancing more interconnected, resilient, and equitable urban systems.

The payoff is practical. For “smart edge cities” to shift from pilots to durable systems, methods must be iterative and accountable. The articles in this Research Topic demonstrate the way: embedding models in theory and validating them against observation; translating cultural and household factors into policy tools; combining infrastructure with long-term plans for regional cooperation; using village-scale evidence to improve public services; and aligning carbon efficiency with spatial spillovers so that lagging regions can catch up. The contributions in this Research Topic offer a concise future agenda for inclusive, connected, low-carbon urban edges designed with communities.

We invite the reader to explore these diverse and compelling contributions as a starting point for a more nuanced, data-informed, and community-engaged approach to the future of the urban periphery.

## Author contributions

SG: Project administration, Conceptualization, Supervision, Resources, Writing – review and editing, Writing – original draft. NM: Supervision, Conceptualization, Writing – review and editing, Resources, Project administration, Writing – original draft.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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