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Spatial justice and the equitable distribution of urban resources for children: A case study of Tianjin, China

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Abstract

As urbanization accelerates, the uneven nature of urban spatial development has led to regional disparities in residents' developmental opportunities. Children, as a significant vulnerable group, find their growth environments and life chances profoundly affected by the urban spatial context. This study, grounded in the theory of spatial justice, analyzes the spatial distribution characteristics of 139 designated Child-Friendly Community (CFC) pilot sites in Tianjin, China. By assessing the alignment of these sites with the city's child population distribution, the research investigates the equity of public resource allocation. The findings reveal a complex picture: while a spatial Gini coefficient of 0.28 suggests a relatively balanced distribution at the macro level, a deeper analysis uncovers a severe "core-periphery" disparity in practical accessibility. Resources are densely concentrated in the central urban districts, leading to walkable service radii. In contrast, peripheral suburban districts face challenges of excessively large service radii and insufficient facility coverage. This analysis underscores a structural imbalance where the allocation of public resources, guided by a top-down, state-led planning model, fails to match the demographic needs and lived realities of children in the urban fringe. The study concludes by proposing policy recommendations focused on optimizing spatial layouts and regulating resource allocation to foster more equitable and just urban development for children, offering insights relevant to other rapidly urbanizing cities facing similar challenges of spatial injustice.

Keywords

Spatial Justice,
Child-Friendly
Community,
Spatial Distribution,
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Highlights for public administration, management and planning:

- Urban planning must transition from macro-level, quota-based distribution metrics to micro-level, accessibility-oriented indicators (e.g., Theoretical Service Radius) to reflect the actual lived experiences of children.
- State-led resource allocation in tiered cities can achieve statistical equity but simultaneously create severe "service deserts" in peripheral suburbs; administrators must recognize and target this hidden spatial mismatch.
- For peripheral areas, planners should abandon the concentric, large-scale facility approach in favor of deploying numerous micro-scale "Satellite Nodes" to ensure walkability.
- Dedicated fiscal transfers and "Child-Friendly Development Funds" are essential management tools to break the path dependency of core-district advantage and directly support infrastructure in lagging urban fringes.

1 Introduction

1.1 Background: Urbanization and the allocation of urban resources for children

As urbanization accelerates globally, the spatial reconfiguration of cities has profoundly reshaped the developmental opportunities available to residents (Reiss 2011). Within this transformation, children constitute a particularly significant yet vulnerable demographic whose well-being is inextricably linked to their immediate physical environment (Kodali et al. 2023). Recognizing this, the United Nations' Child-Friendly Cities Initiative (CFCI) has advocated for placing children's rights at the center of urban planning (UNICEF 2018). China has actively responded to this global agenda, elevating "Child-Friendly City Construction" to a national strategic priority. This commitment is characterized by a powerful, state-led development model capable of rapidly mobilizing resources to improve public service provision across vast urban areas (Nan 2020).

In this context, the municipality of Tianjin serves as a prominent example, having designated 139 "Child-Friendly Community" (CFC) pilot sites. For the purposes of this study, we operationalize "urban resources" specifically as these designated CFC pilot sites and their associated public service facilities. These sites are not merely administrative titles; they represent the physical materialization of state investment intended to provide children with safe play spaces, educational opportunities, and community support. However, while the quantity of these resources reflects a strong administrative will to enhance child welfare, the spatial distribution of these interventions within a rapidly expanding metropolis remains a complex challenge. The critical imperative, therefore, is to examine how these state-allocated resources settle into the pre-existing urban fabric and whether they effectively reach the children who need them most.

1.2 Theoretical lens: From distributive justice to spatial justice

To critically evaluate the allocation of these urban resources, this study adopts the lens of spatial justice. Rooted in the seminal works of critical geographers such as Harvey (1973) and Soja (2010), spatial justice posits that the organization of space is not a neutral backdrop but an active producer of social equity—or inequity. Harvey's foundational argument challenges purely aspatial theories of justice, demonstrating that the geography of public in-

vestment is a primary mechanism for the production of social advantage and disadvantage.

Traditionally, policy evaluations have focused on distributive justice—that is, the fair allocation of "goods" (such as the number of CFCs) across different administrative units. While this metric is essential for assessing the baseline fairness of government supply, it is insufficient for capturing the lived experience of the city's youngest residents. Recent scholarship has reframed children not as passive recipients of protection or care, but as active social agents whose everyday practices—such as moving, playing, and inhabiting urban spaces—constitute meaningful ways of expressing needs and claiming rights. From this perspective, children's engagement with space is understood as a form of social action through which urban environments are interpreted, negotiated, and, to a certain extent, transformed, underscoring the necessity of attending to children's spatial practices when evaluating the justice of urban resource allocation (Christensen & O'Brien 2003; James & Prout 1997; Kytä 2002).

Therefore, a truly just city for children requires moving beyond a singular focus on distribution to encompass recognition and agency. As Fainstein (2010) suggests, equity must be accompanied by the recognition of diverse needs. For children, whose independent mobility is naturally limited, spatial accessibility is the prerequisite for agency. A resource that exists in a district's inventory but is located beyond a child's walkable range (or "service radius") is functionally non-existent to them. Consequently, an analysis of spatial justice in this context must scrutinize not only how many resources are provided (distribution) but where they are located relative to the child population (accessibility), as the latter determines the child's actual "right to the city."

1.3 Global context and comparative perspectives

To situate the Tianjin case within a meaningful global dialogue, it is essential to contrast its development model with those observed in both the Global South and the Global North. Existing literature on urban inequality often bifurcates into two distinct narratives.

In the Global South, particularly in Latin American contexts, research highlights a landscape shaped largely by market forces and the retreat of the state (Roy 2005). Here, socio-spatial segregation is characterized by the proliferation of informal settlements, where the urban poor struggle against a lack

of basic infrastructure and state presence. The challenge is primarily one of absence—the state’s failure to provide resources to marginalized peripheries. Conversely, literature from the Global North (Western context) often assumes a baseline of infrastructure provision and focuses instead on the inclusivity of design and the quality of intergenerational spaces. Recent critical scholarship, such as Kaplan (2024) and Pitsikali et al. (2020), argues that even in resource-rich environments, top-down planning can fail to be “child-friendly” if it creates exclusionary spaces that ignore children’s agency or tokenizes their participation. The challenge here is often one of approach—how public spaces are designed to accommodate the diverse needs of different age groups.

The Chinese context, however, presents a unique “third way” that differs significantly from both models. Unlike the informal urbanization of the Global South, Chinese urbanism is defined by a powerful, high-capacity developmental state that actively plans and finances urban expansion (Ong 2014). Unlike the Western focus on micro-design, the primary challenge in China’s rapid urbanization is macro-structural. The legacy of the hukou system and a concentric “core-periphery” development strategy has created a tiered spatial structure (Chan & Buckingham 2008). In this state-led model, the risk is not necessarily the absence of investment (as in Latin America), nor merely issues of design (as in the West), but rather a structural mismatch where high-standard resources are efficiently allocated but may be spatially concentrated in ways that reinforce historical advantages, potentially creating a distinct form of spatial injustice for children in the urban fringe (Wu 2016).

1.4 The case of Tianjin and research questions

This study investigates these dynamics through the case of Tianjin, a representative megacity in Northern China characterized by a distinct “core-periphery” spatial structure (Zhang et al. 2024). As part of its commitment to social equity, the municipal government has invested significantly in designating 139 Child-Friendly Community (CFC) pilot sites (Tianjin Women and Children Working Committee Office 2023, 2024).

Preliminary analysis of this initiative suggests a complex paradox. On one hand, the aggregate distribution of these resources exhibits a relative statistical balance across administrative populations, reflecting the state’s strong administrative effort to achieve quota-based equity. On the other

hand, the physical reality of the city—particularly the vast distances in the outer suburbs—suggests that this numerical parity may mask profound micro-level spatial mismatches in practical accessibility.

To address this, we operationalize the theory of spatial justice to answer two interrelated questions:

1. What are the spatial characteristics of state-allocated child-friendly resources in a tiered urban structure? We examine whether the distribution follows population needs or adheres to historical core-periphery hierarchies.
2. Does the current allocation model produce a distinct form of spatial injustice regarding accessibility? Beyond the mere presence of facilities, we investigate whether the theoretical service radii in peripheral areas effectively disenfranchise children from accessing these resources, despite the government’s investment.

The remainder of this paper is organized as follows. Section 2 details the study area, data sources, and analytical methods, including the use of Kernel Density Estimation and Theoretical Service Radius (TSR) analysis. Section 3 presents the results, visualizing the tension between resource density and accessibility. Section 4 discusses the implications of these findings for policy optimization, and Section 5 offers concluding recommendations.

2 Research Design

2.1 Study area and data sources

The study area is the municipality of Tianjin, located in the eastern part of the North China Plain, with a total area of 11966.45 square kilometers. The city exhibits a multi-tiered spatial structure, which is officially and functionally divided into four zones: the Core Urban Area, the Inner Suburbs, the Binhai New Area, and the Outer Suburbs. This study utilizes two primary types of data. The first is demographic data from Tianjin’s 7th National Population Census (Tianjin Municipal Bureau of Statistics 2020), which includes information on the total resident population and age structure for each district. It should be noted that while the census provides the most authoritative demographic baseline, it may not fully capture the short-term floating population or students without permanent residency (hukou). However, given the macro-scale of this analysis, these data remain the most reliable proxy for understanding the spatial distribution of demand. The second dataset is the official list

of the 139 designated 'Child-Friendly Community' (CFC) pilot sites. These sites were commissioned by the Tianjin Municipal Government and released in two batches between 2023 and 2024. They are not merely administrative titles but serve as monitored grassroots units providing essential services, play spaces, and community support for children. Additionally, to accurately reflect the effective supply density within inhabited areas, data on the 'built-up area' (urban construction land) for each district was extracted from the Tianjin Statistical Yearbook (2023). This allows for a more realistic calculation of facility density compared to using total administrative area, which includes vast farmlands in peripheral districts.

2.2 Analytical methods

This study employs a multi-method analytical framework to investigate the spatial distribution and equity of CFCs in Tianjin. While advanced GIS techniques (e.g., network analysis) offer high precision, they require detailed road network data that can be inconsistent across urban and rural divides. For the purpose of this study—which aims to evaluate macro-level policy outcomes and structural equity—standardized metrics like the Gini coefficient and Theoretical Service Radius (TSR) provide a robust and comparable baseline for identifying 'core-periphery' disparities.

- **Kernel Density Estimation (KDE):** To visualize the overall spatial concentration of the CFCs, KDE was performed using ArcGIS software. This technique generates a smooth "heat map" that allows for the intuitive identification of high-density "hot spots" and low-density "cold spots," providing a powerful visual representation of the degree of spatial agglomeration.
- **Lorenz Curve and Gini Coefficient:** To provide a quantitative measure of distributive justice, a Lorenz curve was constructed and the Gini coefficient was calculated. This method, adapted from economics, is a standard tool for assessing the equity of public facility distribution (Delbosc & Currie 2011). It visualizes the relationship between the cumulative percentage of the child population and the cumulative percentage of CFC resources across the four major planning zones.
- **Supply Level and Density Analysis:** To assess the provision of resources, two key metrics were calculated for each district and planning zone:

1. **Community Density:** The number of CFCs per square kilometer of built-up area (CFCs/km²). Using the built-up area rather than the total administrative area serves as the denominator to avoid underestimating density in suburban districts with large agricultural territories.
2. **Supply Level:** Defined as the number of CFCs per 10,000 children, serving as a metric for resource abundance relative to the target population.
3. **Accessibility (Theoretical Service Radius, TSR):** To assess the spatial accessibility of the CFCs, the TSR was calculated for each district. The TSR estimates the geographical area served by a public facility. A smaller TSR indicates a denser distribution and higher accessibility, while a larger TSR suggests a sparse distribution and lower accessibility. It is calculated using the formula:

$$R = \sqrt{\frac{A}{N\pi}} \quad (1)$$

where R is the theoretical service radius, A is the area of the region, and N is the number of facilities within that region.

3 Results

3.1 The urban context and the core-periphery structure

To understand the spatial dynamics of the CFC initiative, it is essential to first establish the underlying urban context. Fig. 1 provides a comprehensive overview by integrating four key dimensions of information into a single composite figure. Fig. 1 provides a comprehensive spatial overview. Fig. 1a delineates the four major planning zones. Fig. 1b presents a comparative visualization of total population density versus child population density. These choropleth maps reveal that while the Core Urban Area is highly saturated, significant clusters of child populations are also evident in the 'built-up' centers of the Inner and Outer Suburbs. Against this backdrop, Fig. 1c (Kernel Density Estimation) reveals a dominant, high-density 'hot spot' of CFC resources in the central districts, which tapers off dramatically towards the periphery. This composite visualization establishes the baseline spatial context: the agglomeration of CFC resources closely mirrors the city's administrative center, creating a 'core-periphery' gradient that may not fully align with the wider dispersion of the child population shown in Fig. 1b.

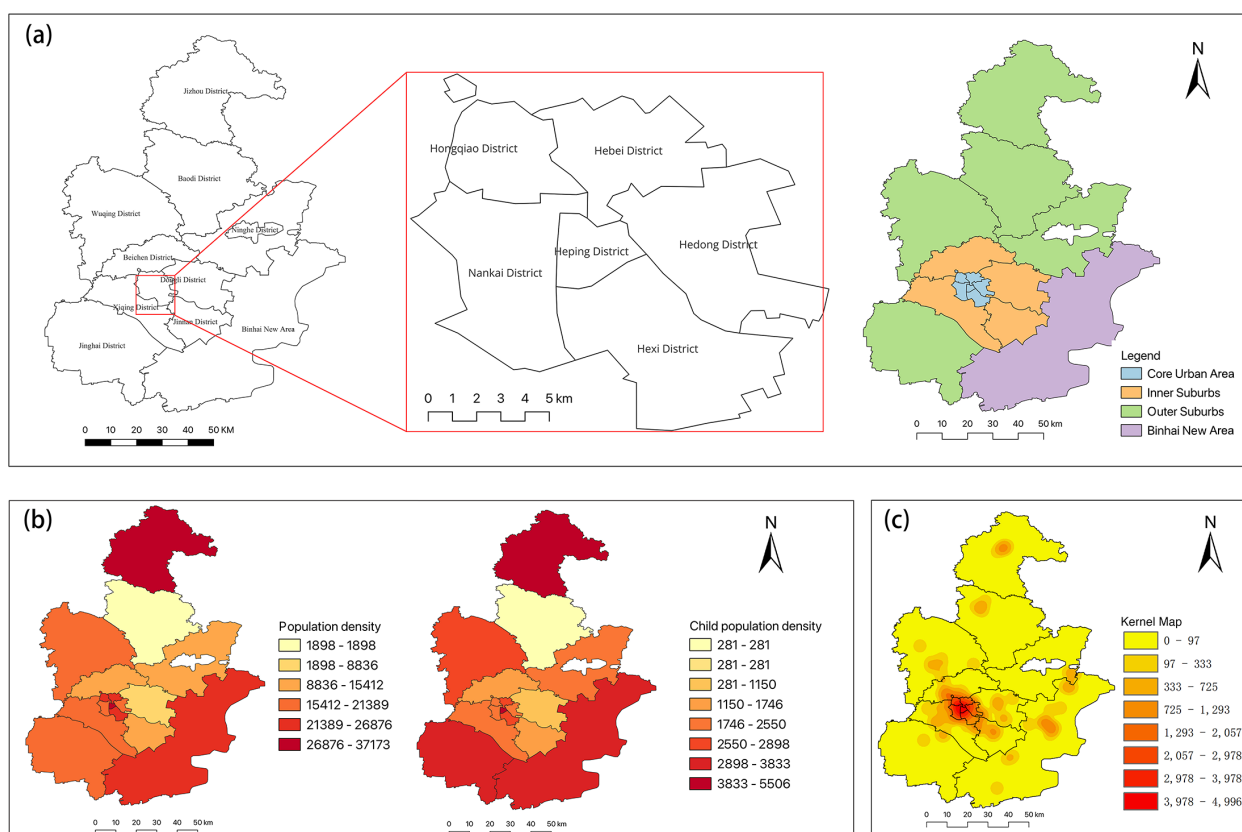


Fig. 1 Spatial Context and Resource Agglomeration in Tianjin. (a) The administrative divisions and the four major tiered planning zones of the municipality. (b) A comparative choropleth analysis illustrating Total Population Density versus Child Population Density (based on 2020 Census data), highlighting significant demographic clusters residing beyond the city core. (c) Kernel Density Estimation (KDE) of the 139 designated Child-Friendly Community (CFC) pilot sites (2023-2024), illustrating a distinct “hot spot” of state investment heavily concentrated in the central historical districts.

3.2 Measuring the inequity of distribution and accessibility

Building on the initial visual analysis, a quantitative assessment was conducted to evaluate the depth of spatial disparity. Fig. 2 (top left) presents the Lorenz curve, which provides a macro-level assessment of distributive equity by plotting the cumulative percentage of the child population against the cumulative share of CFC resources. The curve’s slight deviation from the line of perfect equality results in a calculated Gini coefficient of 0.28. Statistically, this value falls within a range typically interpreted as a “relatively reasonable” distribution. This suggests that at the macro-level of resource allocation, the municipal government has made a concerted administrative effort to balance the quantity of facilities relative to the child population size. However, the bar charts in Fig. 2 (top right) and the detailed data in Table 1 reveal

the limitations of this aggregate balance. A clear stepped hierarchy exists: the Core Urban Area provides approximately 1.25 facilities per 10000 children, whereas the Outer Suburbs—despite hosting 32.2% of the city’s child population—provide only 0.37 (see Table 1). This threefold gap indicates that while the state has successfully deployed resources, children in peripheral zones still face a significantly lower probability of accessing them compared to their urban counterparts.

The analysis of the Theoretical Service Radius (TSR) in Fig. 2 (bottom) uncovers the most critical spatial challenge: practical accessibility. While the average TSR for the Outer Suburbs is 2.49 km (see Table 2), a distance that might appear manageable for vehicular travel, it exceeds the comfortable walking range for children, thereby limiting independent agency. More critically, the district-level breakdown (Fig. 2, bottom right) exposes extreme intra-regional disparities masked by the zone averages.

For instance, Jinghai District exhibits a TSR of 12.51 km, rendering these “community” facilities effectively inaccessible for daily, spontaneous use by children living outside the district center. This confirms that the primary manifestation of spatial injustice in Tianjin is not a total absence of resources, but a structural mismatch where facilities are present but spatially disconnected from the lived realities of children in the urban fringe.

Region	Avg. Theoretical Service Radius (km)
Heping District	0.63
Hexi District	1.10
Nankai District	1.04
Hedong District	1.12
Hebei District	0.93
Hongqiao District	0.87
Core Urban Area	0.98
Dongli District	4.36
Jinnan District	3.93
Xiqing District	3.97
Beichen District	3.90
Inner Suburbs	4.03
Binhai New Area	6.01
Wuqing District	8.46
Baodi District	10.96
Ninghe District	11.73
Jinghai District	12.51
Jizhou District	10.96
Outer Suburbs	10.38

Table 2 Theoretical Service Radius (TSR) of CFCs by planning zone and select districtss

3.3 Multi-dimensional analysis of the supply-demand mismatch

To synthesize the complex relationship between resource provision and demographic structure, Fig. 3 presents a multi-dimensional radar chart comparing the four planning zones across five key indicators. This visualization allows for a holistic assessment of the “profile” of each zone, revealing a distinct structural divergence between the city’s center and its edge.

The chart illustrates a fundamental inversion of supply and demand profiles. The Core Urban Area (blue line) exhibits a shape heavily skewed towards resource dominance. It achieves maximum values on the axes for Community Density (calculated by built-up area), Supply Level, and Accessibility (where a higher value indicates a smaller, more fa-

vorable service radius). However, it scores the lowest on the Child Ratio axis, reflecting a demographic structure with a lower proportion of children.

In sharp contrast, the Outer Suburbs (yellow line) present the opposite profile. This zone creates a prominent spike on the Child Ratio axis, indicating the highest relative demographic demand. Yet, its performance contracts sharply on the resource axes, particularly for Supply Level and Accessibility. The Inner Suburbs and Binhai New Area display transitional shapes, situated between these two extremes.

This visual dichotomy—where the polygon representing high resource capacity (the Core) barely overlaps with the polygon representing high demographic need (the Outer Suburbs)—powerfully encapsulates the structural mismatch. It demonstrates that while the city has successfully concentrated high-quality resources in its historic center, the current allocation model has yet to fully adapt to the demographic reality that the child population is increasingly significant in the peripheral zones.

4 Discussion

4.1 The Paradox of state-led equity: Distributive balance vs. spatial exclusion

The empirical results of this study illuminate a profound “equity paradox” within Tianjin’s child-friendly city construction: the simultaneous existence of distributive balance at the macro level and severe spatial exclusion at the micro level. The calculated Gini coefficient of 0.28 (Fig. 2) serves as a compelling starting point for this theoretical interrogation. Falling well within the range typically defined as “relatively reasonable” by international standards, this metric suggests that from the perspective of distributive justice—as originally conceptualized by Harvey (1973)—the municipal government has effectively fulfilled its administrative mandate. By ensuring that the quantity of CFC resources generally correlates with the administrative distribution of the child population, the state has demonstrated a high capacity for resource mobilization and “quota-based” fairness. This achievement highlights the unique advantage of the Chinese state-led planning model, which can rapidly direct public goods to vast administrative units to meet baseline coverage target (Ong 2014).

However, when viewed through the lens of Soja (2010) spatial justice, this statistical equilibrium reveals its fragility. Soja argues that space is not merely a neutral container for social data but an active force that produces advantage and dis-

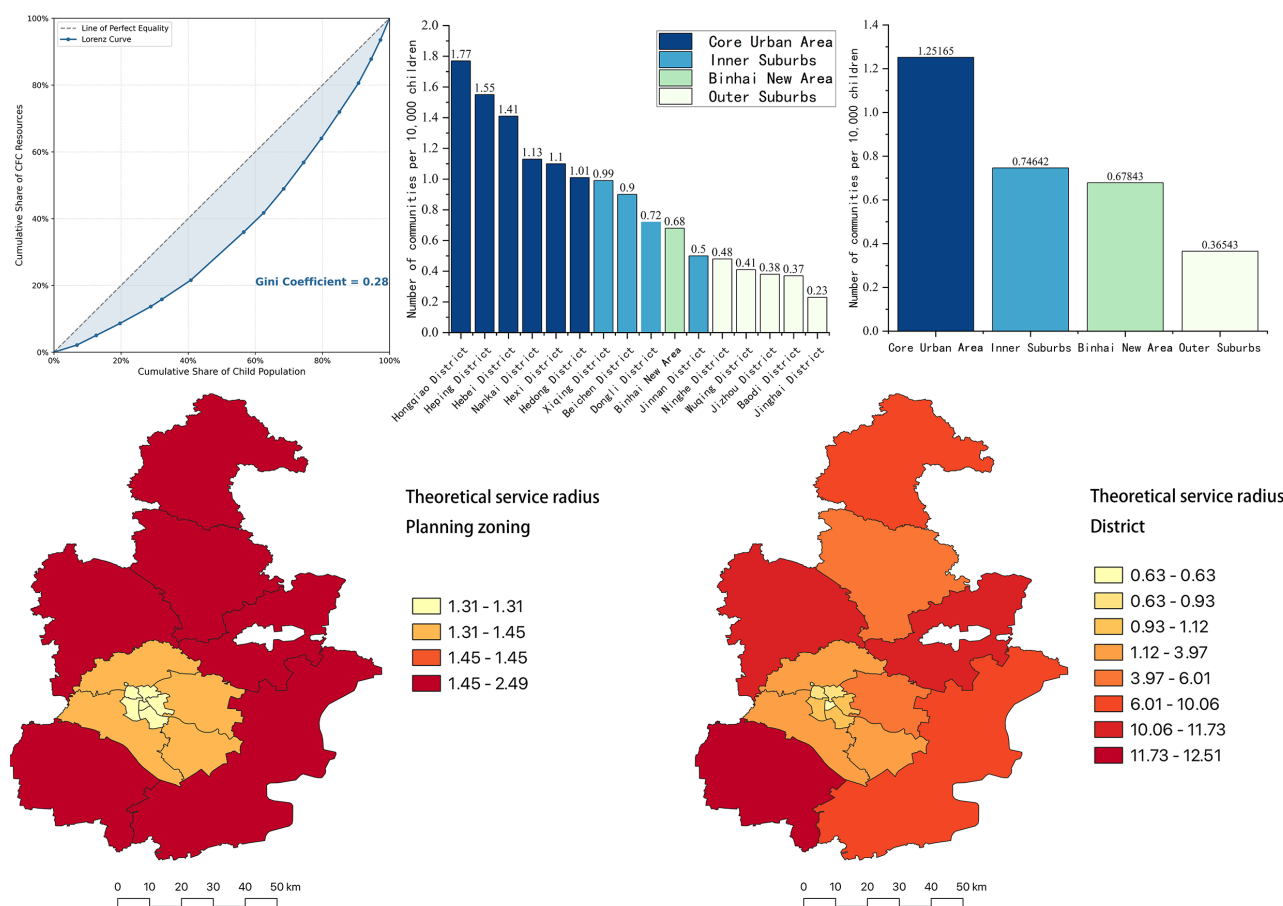


Fig. 2 Quantitative assessment of equity: distribution vs. accessibility. Top Left: Top Left: The Lorenz Curve and spatial Gini Coefficient (0.28) indicate a relatively balanced macro-level distribution of Child-Friendly Communities (CFCs) relative to the child population. Top Right: Bar charts revealing a tiered provision structure in the “Supply Level” (CFCs per 10,000 children) across different planning zones. Bottom: Maps visualizing the Theoretical Service Radius (TSR). The left map demonstrates the average TSR by Planning Zone (reaching an impractical 2.49 km in the Outer Suburbs), while the right map details the TSR at the district level, exposing extreme accessibility deficits and “service deserts” in peripheral areas like Jinghai (12.51 km).

Planning Zone	No. of CFCs	Percentage of Total	Built-up Area (km ²)	Facility Density (CFCs/km ²)	Supply Level (CFCs per 10,000 children)
Core Urban Area	60	43.2%	180.55	0.34	1.25
Inner Suburbs	37	26.6%	1888.66	0.12	0.75
Binhai New Area	20	14.4%	2270.00	0.05	0.68
Outer Suburbs	22	15.8%	7444.90	0.10	0.37

Table 1 Distribution characteristics of CFCs across Tianjin’s planning zones

advantage. The Gini coefficient, being an aspatial metric derived from administrative units, obscures the geography of provision (Geurs & Wee 2004). The analysis of the Theoretical Service Radius (TSR) exposes the “hidden” injustice behind the Gini index: while facilities are administratively allocated to the periphery, they are spatially positioned be-

yond the reach of their intended users. The average TSR of 2.49 km in the Outer Suburbs, with extremes reaching 12.51 km in Jinghai District (Table 2), indicates that for a child relying on walking or short-distance travel, these resources are effectively non-existent.

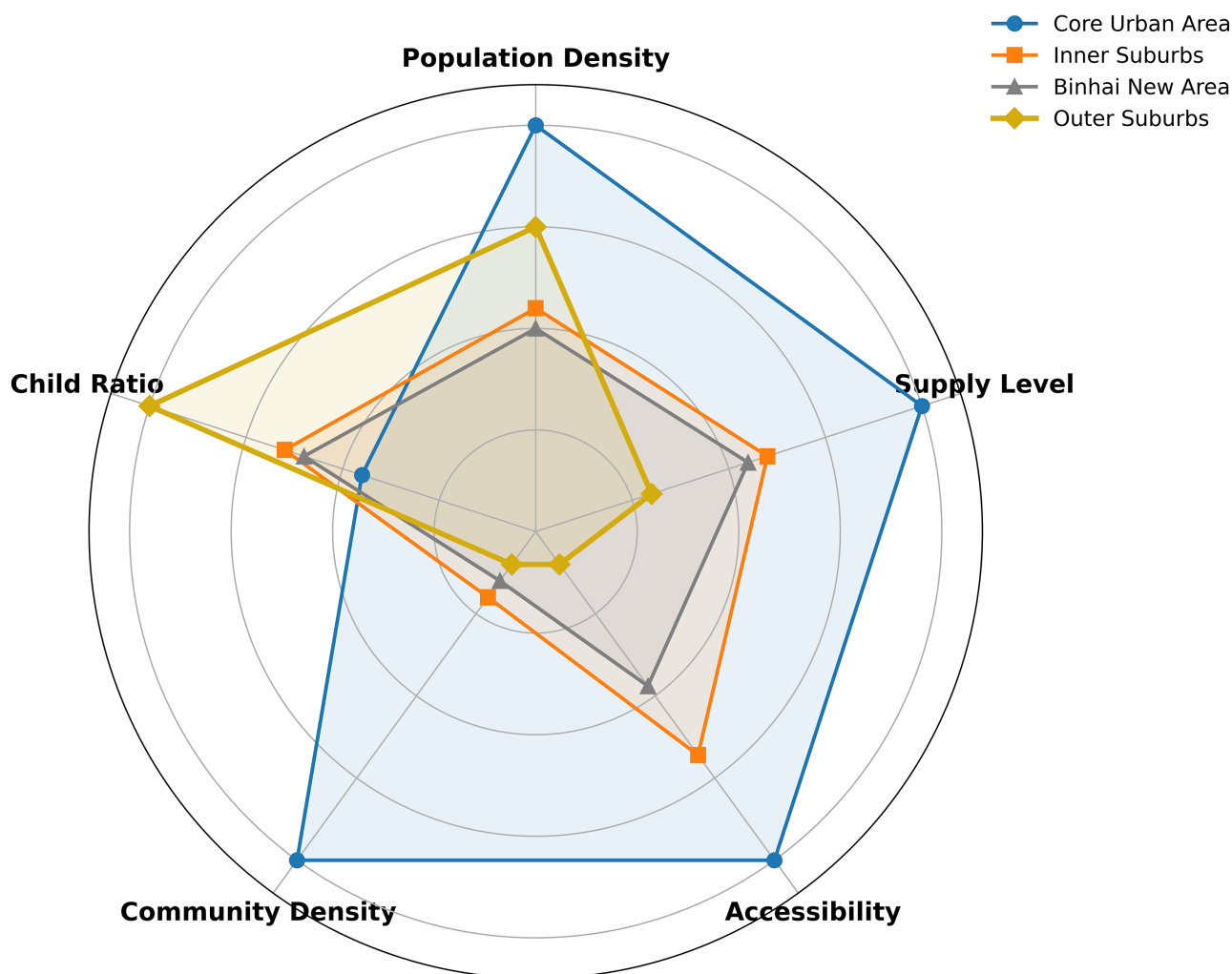


Fig. 3 Multi-dimensional Analysis of Supply-Demand Mismatch The chart contrasts the profiles of the four planning zones across five key socio-spatial indicators. It visually demonstrates a structural inversion, e.g.: The Core Urban Area (Blue) excels in state-provided resource indicators (Supply Level, Accessibility, Community Density) but features a lower Child Ratio.

This disconnect between “administrative presence” and “physical absence” calls for a critical re-evaluation of urban equity using [Fainstein \(2010\)](#) framework of the “Just City”. Fainstein critiques the reduction of justice to simple distribution, advocating instead for a model that includes recognition and the development of human capabilities. For children, a demographic defined by limited independent mobility, spatial accessibility is not merely a technical convenience but a fundamental prerequisite for exercising their “right to the city”. When state planning prioritizes the numerical coverage of facilities over their walkable accessibility, it inadvertently creates a form of “spatial exclusion.” Consequently, the primary manifestation of injustice in Tianjin is not the traditional “scarcity of re-

sources” often observed in the Global South, but rather a “structural mismatch” of high-quality assets. Children in the urban fringe are not excluded from the government’s investment budget—as evidenced by the fair Gini score—but they are excluded from the lived space of the community. This finding suggests that without a paradigm shift from “quantity-oriented distribution” to “accessibility-oriented recognition,” the potential for these resources to enhance children’s capabilities will remain unrealized, regardless of the volume of state investment.

4.2 Mechanisms of structural mismatch: A comparative reflection

The spatial exclusion identified above is not an accidental byproduct of urbanization but the result of deeply entrenched structural mechanisms. Fig. 4 synthesizes these dynamics into a logic of “cumulative causation”, illustrating how historical, spatial, and institutional factors interact to reinforce the “core-periphery” divide (Gong & Binz 2023). Unlike the distinct socio-spatial segregation often driven by market forces or racial divisions in Western contexts, the disparity in Tianjin is fundamentally shaped by a state-led “concentric zone” development model (Wu 2016).

As illustrated in the “Historical Development” and “Spatial Structure” quadrants of Fig. 4, the Core Urban Area has historically monopolized public investment, creating a “lock-in” effect (Wei et al. 2017). High-quality infrastructure attracts population and economic activity, which in turn justifies further state investment in high-standard facilities like CFCs. Conversely, the peripheral districts, often transitioning from rural to urban governance, suffer from “institutional inertia.” (Li et al. 2024) Despite recent urbanization, their fiscal capacity and public service foundations remain weak (as shown in the “Policy & Institutions” quadrant). When a “one-size-fits-all” resource allocation policy is applied to this uneven terrain, it inevitably favors the path-dependent advantages of the core, creating a self-reinforcing cycle of polarization.

To understand the specificity of this mechanism, it is instructive to place the Tianjin case in a global comparative perspective.

- **Contrast with the Global South:** In many Latin American cities, spatial injustice often stems from state withdrawal or incapacity, leading to the proliferation of informal settlements (favelas) where services are entirely absent (Glebbeek and Koonings 2016). In Tianjin, the state is powerfully present. The issue is not the absence of planning, but the rigidity of the planning hierarchy. The state has the capacity to build, but it builds according to a hierarchical logic that prioritizes the “efficiency” of the center over the “equity” of the edge.
- **Contrast with the Global North:** In Western urban discourse, critiques of “child-friendly” initiatives often focus on micro-level issues such as gentrification, design inclusivity, or the privatization of public space (Kaplan 2024). However, the primary challenge in Tianjin is macro-structural. The concentric urban form

dictates that resources decay with distance from the center. The “spatial mismatch” here is physical and scale-based, rather than purely social or design-based.

Furthermore, this structural mismatch is exacerbated by the performance evaluation metrics inherent in the administrative system. As indicated in the “Socio-economic Condition” quadrant of Fig. 4, the high population density of the core allows for an efficient “return on investment” regarding service coverage metrics. A single CFC in the core can statistically “serve” thousands of children, fulfilling policy quotas efficiently. In contrast, the sparse population of the periphery renders the same investment “inefficient” by traditional metrics. This “efficiency-oriented” logic drives planners to concentrate resources where they are most visible and statistically significant, inadvertently neglecting the “accessibility-oriented” needs of dispersed populations in the Outer Suburbs.

4.3 Pathways to spatial justice: Towards an accessibility-oriented planning model

To redress the structural imbalances identified above, urban planning paradigms must shift from a “supply-oriented” logic—focused on meeting administrative quotas—to an “accessibility-oriented” model focused on the lived experience of the child (Handy 2020). Based on the empirical findings, this study proposes a three-tiered optimization pathway, visualized in Fig. 5, to transition from concentric agglomeration to a networked spatial equity. First, the metric of evaluation must shift from “Quantity” to “Accessibility.” Current policies often rely on the indicator of “CFCs per 10000 residents”. While useful for macro-allocation, this metric is blind to spatial friction (Yan et al. 2025). We argue that the Theoretical Service Radius (TSR) and the concept of the “15-minute life circle” should become the primary governance indicators (Moreno et al. 2021). For children, the value of a facility is defined by its walkability. Therefore, policy success should not be measured by how many facilities are built, but by the percentage of the child population residing within a walkable service radius. This shift operationalizes Fainstein’s capabilities approach, ensuring that the “right to the city” is physically exercisable.

Second, the spatial structure must be reconfigured through a “Networked Satellite Model.” As illustrated in Fig. 5, the current “one-size-fits-all” approach fails because it applies a core-centric building standard to peripheral realities.

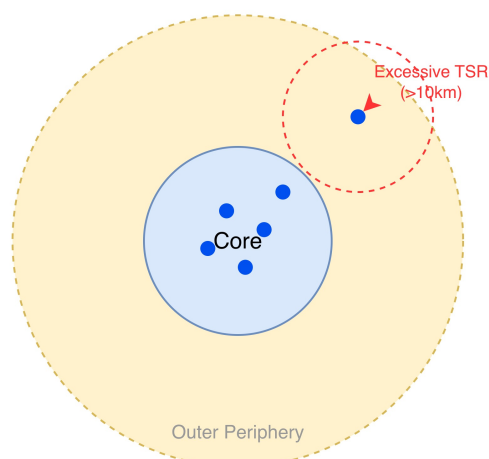


Fig. 4 The mechanisms of spatial disparity: A circular logic of cumulative causation. The diagram synthesizes the structural factors driving the core-periphery divide in Tianjin by illustrating how path-dependent historical development and a concentric spatial structure interact with uneven policy support and fiscal capacity disparities.

- In the Core Urban Area (Fig. 5, Right - Blue Zone): The strategy should focus on "qualitative optimization." Since density is already high, the priority is not adding new nodes but upgrading existing facilities to be more inclusive and intergenerational.
- In the Outer Suburbs (Fig. 5, Right - Yellow Zone): We propose a "Center + Satellite" hi-

erarchy. The current pattern of "Concentric Agglomeration" (Fig. 5A) leaves vast "service deserts" due to excessive radii. The proposed solution (Fig. 5B) advocates for a decentralized network. Instead of investing in a few large-scale, comprehensive centers that are hard to reach, resources should be redistributed to create numerous smaller "Satellite Nodes". These micro-scale facilities—embed-

A. Status Quo: Concentric Agglomeration



B. Proposed: Networked Satellite Model

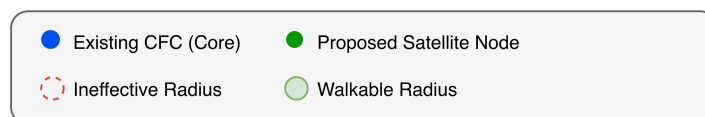
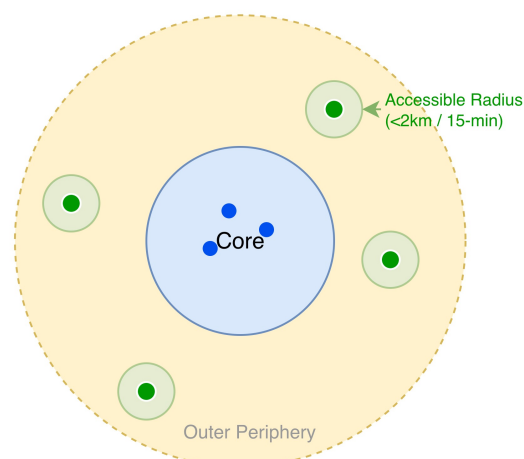


Fig. 5 Proposed Spatial Optimization Model: From Concentric Agglomeration to Networked Equality. (A) Status Quo: The current model relies on concentric agglomeration, where Child-Friendly Community (CFC) resources are aggregated in the core, creating “service deserts” in the periphery characterized by excessive, unwalkable service radii (red dashed circles). (B) Proposed Model: The “Networked Satellite Model” advocates for decentralizing resources in the periphery. By deploying numerous micro-scale “Satellite Nodes” (green dots) instead of large centers, the model ensures that the effective service radius (green solid circles) remains within a walkable, 15-minute child-friendly range, thereby mitigating spatial exclusion.

ded in villages or subdivision clusters—sacrifice scale efficiency for spatial coverage, effectively reducing the service radius to a child-friendly scale (< 2 km) (Design 2016).

Third, institutional mechanisms must provide “Spatial Compensation.” To overcome the “cumulative causation” of the core-periphery divide (as shown in Fig. 4), a neutral market or flat policy is insufficient. A mechanism of spatial compensation is required (OECD 2025). This involves establishing a dedicated vertical fiscal transfer or a “Child-Friendly Development Fund” specifically targeting districts with high TSR values (Liu et al. 2024). By decoupling resource allocation from the local economic base of peripheral districts, the state can actively intervene to break the lock-in effect, directing high-quality public resources to where they are most spatially needed rather than where they are most efficiently deployed (Ehrlich & Overman 2020).

5 Conclusion and prospects

5.1 Conclusion: From administrative equity to spatial mismatch

This study investigates the spatial distribution of state-allocated child-friendly resources in Tianjin, revealing a profound “equity paradox” under a state-led planning model. The key takeaways are:

- **Concentric Agglomeration vs. Demographic Reality:** The designated Child-Friendly Community (CFC) sites exhibit a strong “core-periphery” gradient. State resources are highly concentrated in the historic Core Urban Area, failing to align with the significant demographic reality that 32.2% of the city’s child population resides in the Outer Suburbs.
- **The Illusion of Administrative Equity:** At the macro level, the allocation appears statistically equitable, evidenced by a relatively reasonable Gini coefficient of 0.28. This demonstrates the state’s capacity to mobilize re-

sources to meet quota-based targets across broad administrative divisions.

- **Micro-level Crisis of Accessibility:** In spatial reality, this statistical balance masks severe inequity. Theoretical Service Radius (TSR) analysis reveals a crisis of accessibility in the periphery (e.g., radii exceeding 12 km in Jinghai). Facilities are administratively present but functionally unreachable for children.
- **Redefining Spatial Injustice:** The primary challenge in rapidly urbanizing tiered cities is no longer a simple scarcity of resources, but a structural “spatial mismatch.” Without shifting from quantity-oriented administrative metrics to accessibility-oriented indicators (walkability), state investments risk becoming mere “statistics on paper” that fail to enhance the daily lives and capabilities of children in marginalized urban fringes.

5.2 Limitations and future research

While this study provides a critical baseline assessment, several limitations should be acknowledged to guide future research.

First, the measurement of accessibility relies on the Theoretical Service Radius (TSR). As a Euclidean proxy, TSR provides a standardized metric for macro-level comparison but does not account for the complexities of the actual road network, traffic conditions, or physical barriers (e.g., highways, rivers). Future studies could employ more advanced GIS methods, such as Network Analysis or the Two-Step Floating Catchment Area (2SFCA) method, to model travel times with greater precision and reflect real-world accessibility.

Second, the demographic analysis is based on the 2020 National Census. While authoritative, this static dataset implies a limitation in capturing the floating population, particularly the children of migrant workers who may lack local household registration (hukou) but reside in the city. These groups are often the most vulnerable to spatial exclusion. Future research could integrate dynamic multi-source data, such as mobile phone signaling or LBS (Location-Based Services) data, to capture the real-time spatial distribution of actual service demand.

Third, this study adopts a supply-side quantitative perspective. It identifies where resources are located but cannot explain how they are utilized or perceived by children. The “lived experience” of spatial justice remains a black box. Subsequent research should complement these quantita-

tive findings with qualitative methodologies, such as participatory mapping with children, interviews, or behavioral observations. This would provide necessary insight into the micro-scale barriers—social, safety, or design-related—that may further inhibit children from accessing these designated community spaces.

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