Research Paper

Improving social resilience in shrinking cities through social infrastructure regeneration

An investigation from Hegang, China

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Abstract

In the context of globalization, the formation of new economic systems and the information revolution have led to the breakthrough of urban development through geographical and spatial limitations, resulting in the concentration of key resources and infrastructure in "Global Cities". The "Rust Belt" region in Northeast China is generally facing shrinkage, leading to the decline of physical space and indirectly triggering a structural crisis at the social level. Social infrastructure and social capital provide coping strategies at both the social and spatial dimensions and become an effective tool to enhance the social resilience of shrinking cities. As a typical shrinking city in Northeast China, Hegang is facing the crisis of social infrastructure deterioration and the risk of social capital leakage. This study takes a social perspective, based on a review of social infrastructure theory and the production path of social resilience for shrinkage. On the one hand, we summarize the role of social infrastructure and social capital in coping with shrinkage, and on the other hand, we uncover the regular characteristics of social infrastructure supply and demand in shrinking cities and propose typical experiences such as regeneration coping strategies for social resilience enhancement.

Keywords

Social Infrastructure; Social Resilience; Social Capital; Shrinking Cities; Governance Policies

1. Introduction

In the context of globalization, key resources and infrastructures are concentrated in "global cities", and the formation of new economic systems and the information revolution have led to the breakthrough of urban economic and social development through geographical and spatial restrictions, promoting the global concentration and dispersion of capital and population, and inevitably causing the phenomenon of urban shrinkage in local regions(Florida, 2018; Martinez-Fernandez et al., 2012). It is generally believed that urban shrinkage is a multidimensional process, including economic, demographic, geographic, and social aspects, which is characterized by industrial decline, population loss, and employment decline in

cities or some regions, which in turn leads to a structural crisis in urban economy and society(Martinez-Fernandez et al., 2012).

Unlike the shrinking characteristics of Western cities, the shrinkage in China is generally manifested as urbanization and shrinkage in parallel, presenting with the typical perforated characteristics in the urban centers on the one hand, and the development of large residential areas in the suburbs and the construction of new cities on the other. In the context of elite-driven spatial development, grassroots citizens' demands are often difficult to be met, which then translates into a contradiction between top-down spatial development and bottom-up spatial consumption(Yang, 2022). In this context, the urban economic and institutional environments face new challenges. The differences between the social and built environment of public facilities and open spaces, which are the carriers of social capital formation, lead to the unequal spatial distribution of social welfare, resulting in the dissolution of social networks in local areas(Ročak et al., 2016), i.e., the low quality of public services enjoyed by some disadvantaged groups makes it difficult to form a high level of social capital, which in turn leads to the risk of further shrinkage in some areas.

The stock of social capital generated by social infrastructure provides an endogenous advantage for shrinking cities, which is the product of accumulated social practices over time and does not disappear rapidly with the decline of physical space(Leetmaa et al., 2015) and has a longer "self-sustaining" effect(Kinossian, 2018; Rocak, 2019), specifically in terms of providing social support and collective efficacy(Lima et al., 2020), creating trust in communities, enhancing place attachment, promoting civic engagement(Guimaraes et al., 2016), and empowering grassroots societies(Rocak, 2019), which have become effective tools for buffering the consequences of shrinkage and improving the quality of social life and social resilience(Ročak et al., 2016). In the face of external shocks brought by urban shrinkage, social infrastructure can, on the one hand, perpetuate the stability of urban social structures and reshape local social networks in the context of built environment decay; on the other hand, in the context of financial constraints, the construction of critical social infrastructure, i.e., key nodes that carry social capital and are frequently used by residents, can be an effective tool to maintain social cohesion and weaken the impact on urban software, i.e., social norms, values and ways of social interaction, and Urban mindware, i.e., residents' perceptions of the shrinking image(Hospers, 2014).

Therefore, this study, by combing social infrastructure theories and social resilience production paths, combined with the investigation example of a typical shrinking city - Hegang, summarizes the role of social infrastructure and social capital in coping with shrinkage on the one hand, and on the other hand, uncovers the regular characteristics of the supply and demand level of social infrastructure in shrinking cities, and proposes typical experiences such as updated coping strategies for social resilience enhancement.

2. Social Infrastructure Theory and its Shrinkage Response Approach

2.1. Theoretical foundation: the social and political nature of space

Social Infrastructure (SI) theory is an expansion of the concept of public space and infrastructure by sociologists, which is based on both social and political dimensions.

Sociality allows the value of space to be re-examined to reflect the actual needs of residents.The "third place" theory proposed by Oldenburg suggests that spaces such as cafes, community centers, beauty salons, and bars, in addition to homes and workplaces, allow people to get together after work and constitute the core of the social vitality of a community(Hendershott and Oldenburg, 1991). This concept was gradually extended to public spaces such as streets, parks, restaurants, and museums as physical spatial carriers of social processes(Zukin, 1995) and as areas and social contexts where individuals interact socially with others and develop a sense of community. And as the infrastructure of physical space, but also the place

of productive life practices, people's practical activities in space produce social networks, material symbols. In the process of social interaction, people recognize the qualities of civic culture, tolerance, and collective life, which transcend the value of a single interaction between individuals and produce a "social surplus"(Amin, 2013).

Political oriented neo-Marxist critique of the globalization of capital. Foreign scholars have critiqued the political economy of capitalist globalization and modernity in terms of the fragmentation, homogenization, and hierarchical structure of infrastructure networks that it has brought about, arguing that this landscape pattern has resulted in barriers to use, segregation of the public sphere, and the closure of land and facilities, a process that is accompanied by the fragmentation and deconstruction of social space. The gaps in service and maintenance of existing infrastructure and the difficulty of equitably allocating new infrastructure in a market-based context have resulted in a decline in the accessibility and accessibility of some infrastructure, exacerbating social inequalities while creating inequalities in the social capital of residents and differences in the resilience and sustainability of community development(Brown and Barber, 2012). As a result, infrastructure development in cities coalesces the interests of a few elite groups and excludes disadvantaged groups(Warf, 2003). As a result, in informal settlements that lack infrastructure support, disadvantaged groups are left to build "micro-collectives" around established infrastructure to support daily life(Amin, 2014). The concept of social infrastructure has evolved on this basis.

2.2. Conceptual development: two-way expansion of the social and political dimensions

Social infrastructure is a physical space that facilitates the occurrence of social interactions, focusing on the role of social support for vulnerable groups in coping with the occurrence of external disasters, implying both spatial social and political dimensions. Previously, the concept of social infrastructure developed through three stages(Latham and Layton, 2022). In early urban societies, there was no formal infrastructure, when people themselves were the infrastructure, and people formed social networks of mutual support through blood and geopolitical ties, and thus had the power to live collectively(Simone, 2021). With the formation of formal infrastructure, the focus on infrastructure gradually shifted from human society to the social nature of physical space(Latham and Layton, 2022). In the third stage, the category of infrastructure gradually broadens to include public functions with social care such as health care and education, which are seen as the basis for the normal functioning of society. On this basis, Klinenberg defines social infrastructure as physical space that can facilitate social interaction(Klinenberg, 2019), which includes four categories of community facilities, places of worship, commercial facilities, and parks and other open spaces(Fraser et al., 2022) (Figure 1).

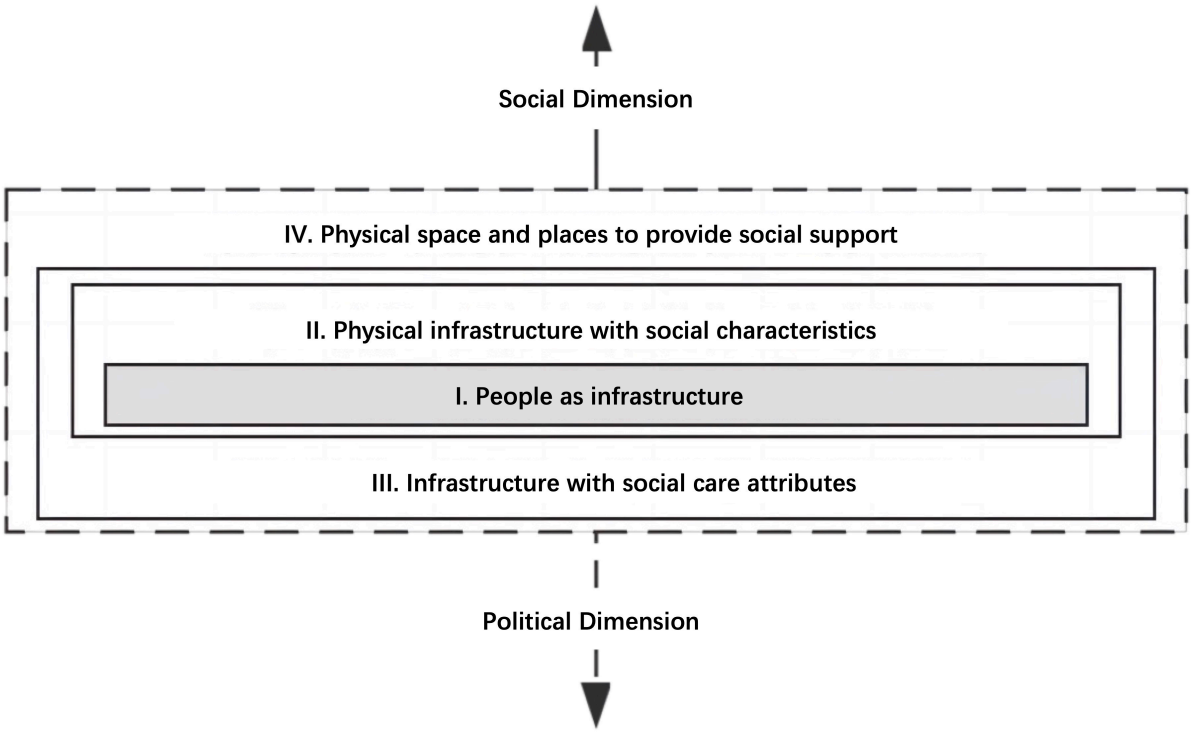


Figure 1 Evolution of the concept of social infrastructure

In 2018, sociologist Eric Klinenberg from New York University conducted a study on the impact of the 1995 Chicago heatwave on urban communities. He found significant differences in mortality rates between two impoverished communities in their processes and outcomes of dealing with the external disaster. The cause of these disparities was attributed to the level of social interaction rather than income differences, as the former played a crucial role in enhancing the resilience during the disaster response and the subsequent recovery. In communities with lower mortality rates, there tended to be spaces available for residents to engage in daily communication and develop habits of visiting one another. During extreme heatwaves, people were more likely to greet each other and visit elderly, vulnerable, and impoverished neighbors, effectively reducing the mortality rates among the disadvantaged groups within the community. Based on these findings, Klinenberg defined social infrastructure as follows:

"Public institutions such as libraries, schools, playgrounds, parks, sports fields, and swimming pools are crucial components of social infrastructure. Sidewalks, courtyards, community gardens, and other green spaces that attract people to public areas are also part of it. Community organizations, including churches and civic associations, function as social infrastructure when they have a fixed physical space for people to gather(Eric Klinenberg, 2018)*."*

2.3. Theoretical Connotation: "Social" and "Supportive" Public Spaces

2.3.1. Public Spaces with "Social" Characteristics

Social infrastructure is a unified entity that encompasses two concepts, namely "social" and "infrastructure" (space), which are dialectically interconnected. Its philosophical foundation can be traced back to the research on social spatial relations by the neo-Marxist school, forming a rich theoretical framework (Figure 2). Henri Lefebvre argues that "social space is a (social) product," suggesting that natural spaces with original attributes gradually transform into spaces with social characteristics through human social production and reproduction, and this specific space, in turn, influences social reproduction. David Harvey views spatial forms as the external manifestation of social processes, and social processes are also

products of spatial forms. Pierre Bourdieu adds a third dimension to social spatial relations, which is the historicity of space, forming the "existence" that is jointly shaped by spatiality, sociality, and historicity. He believes that there is a dialectical relationship not only between society and space but also between time and space, and between time and society.

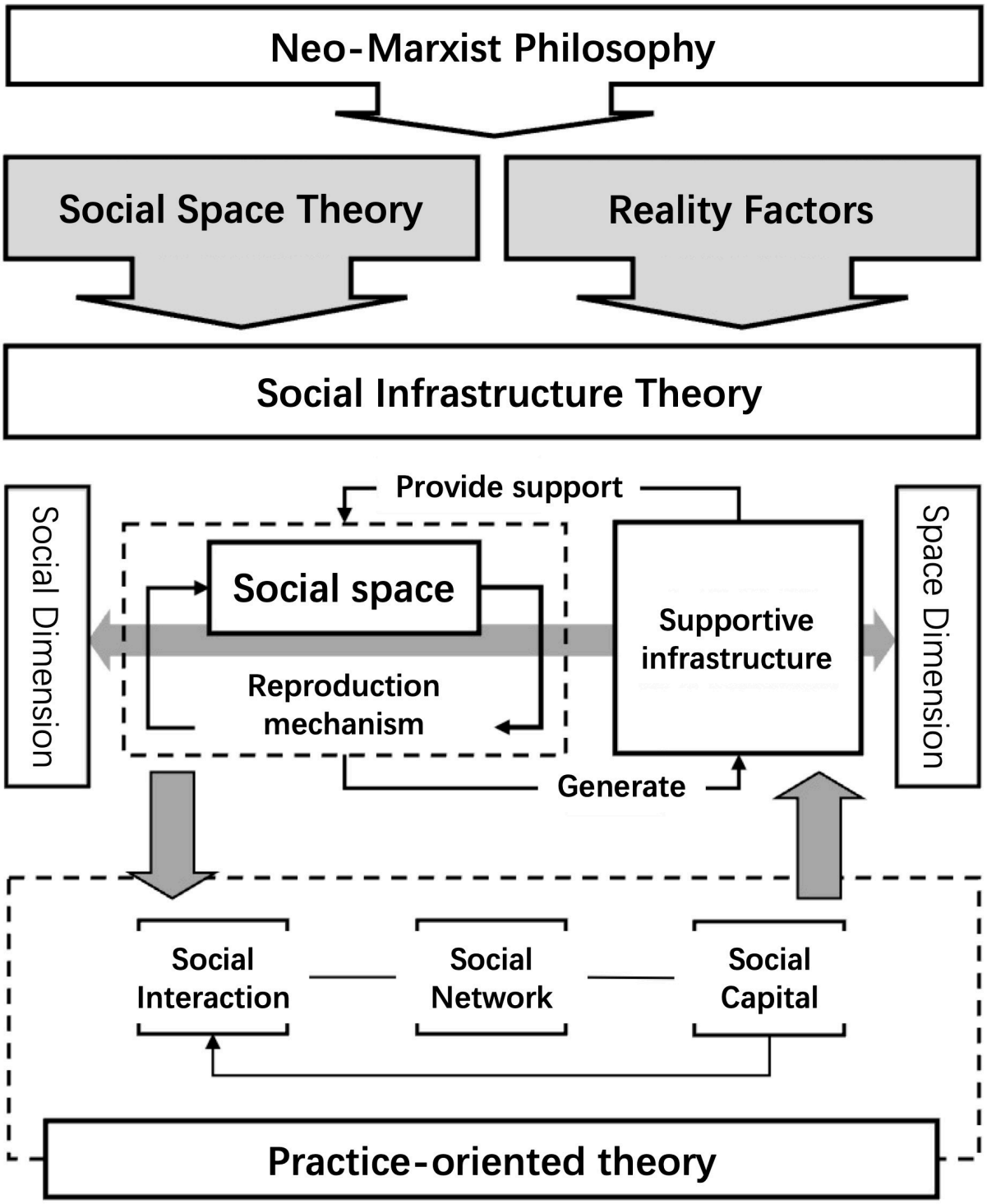


Figure 2 Social Infrastructure Theory System

The theory of social infrastructure is grounded in the process of spatial reproduction and focuses on the mechanisms of social formation. Social infrastructure itself is a physical space imbued with social characteristics, and this social production stems from everyday life practices, namely social interactions(Klinenberg, 2019). Social interactions occurring within the spatial realm shape regional social networks and generate social capital, which, in turn, facilitates further social interactions (Figure 3). The sociality produced through this process is essentially a collective set of attributes of individuals participating in social interactions, leaving an imprint on the daily lives of residents. This fundamental difference is what sets apart Klinenberg's theory of social infrastructure from previous studies on spatial sociality.

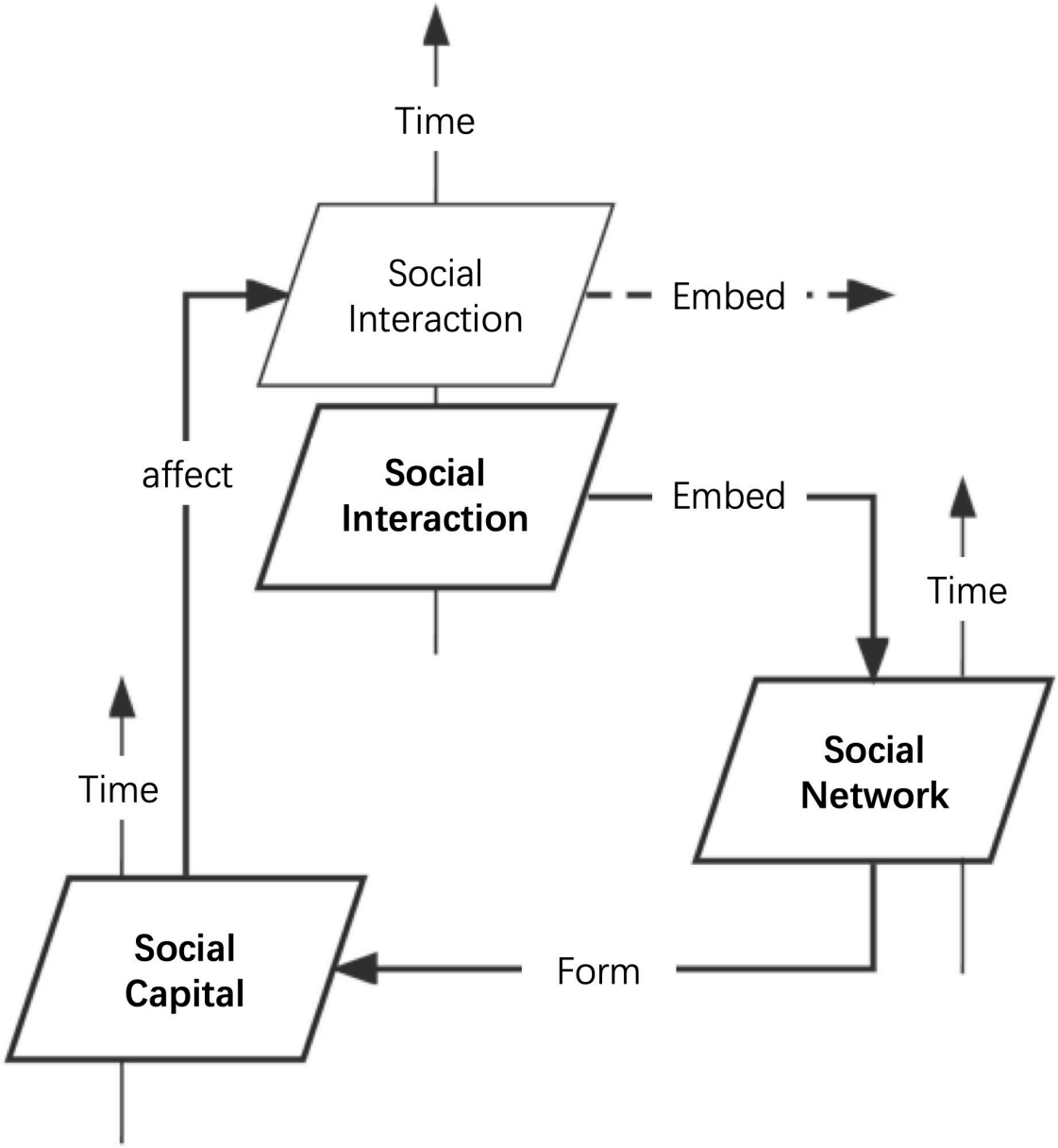


Figure 3 Comparison of differences in infrastructure supportability

2.3.2. Infrastructure with "Supportive" Characteristics

Social infrastructure is distinct from public service facilities, and its key difference lies in the attribute of "infrastructure," specifically the connotation of "supportive." It is proposed in response to the multiple realities of urban development, differentiating itself from the "hard support" provided by physical infrastructure. Social infrastructure, through the physical spaces that facilitate social interactions and the institutional infrastructure embedded within those spaces, provides an indirect form of "soft support"(Klinenberg, 2019) (Figure 4).

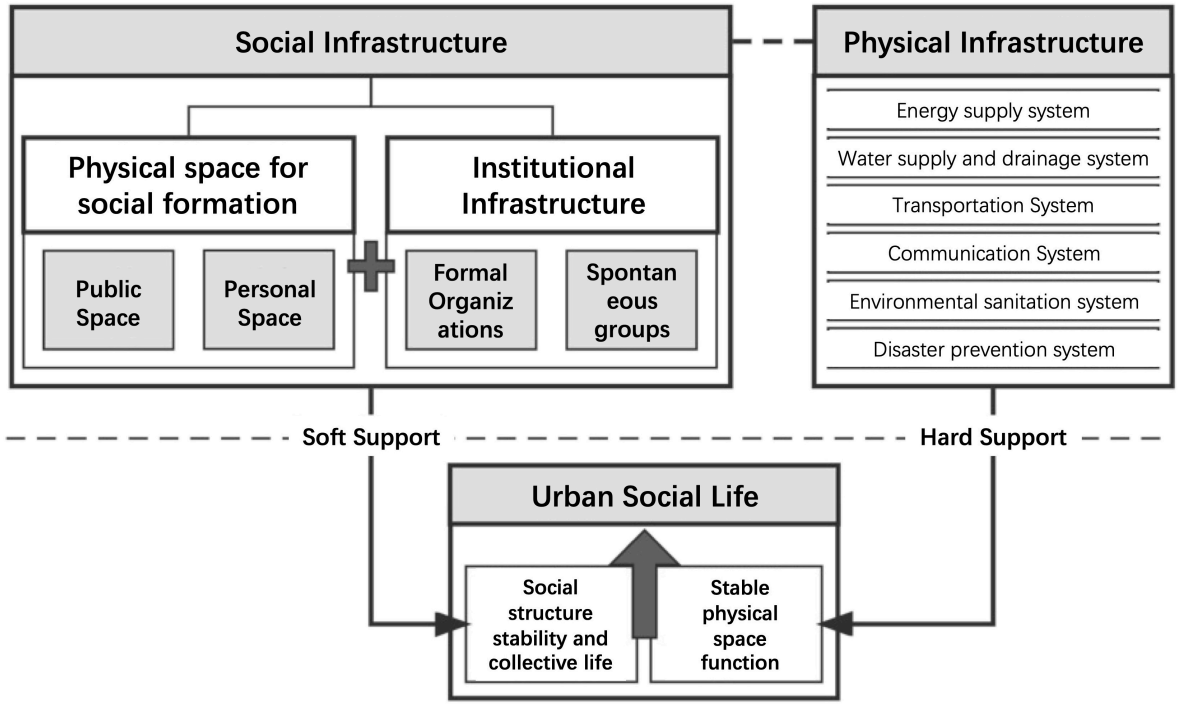


Figure 4 Comparison of differences in infrastructure supportability

This notion of "supportive" is understood as a form of "collective efficacy"(Kathleen A. Cagney et al., 2016; Sampson et al., 1997) emanating from civil society, which refers to the collective social capital embedded within social networks(Bourdieu, 2021; Coleman, 2000; Lin, 2002; Putnam, 2020) and can be acquired through social interactions. Based on the differences in network composition, social capital can be categorized into bonding, bridging, and linking social capital. The former two reflect horizontal relationships, while the latter reflects vertical relationships(Daniel P. Aldrich and Michelle A. Meyer, 2015a; Szreter and Woolcock, 2004). Higher levels of bonding and bridging social capital contribute to the formation of linking social capital(Agger and Jensen, 2015). Specifically, bonding social capital primarily forms within homogeneous groups characterized by socio-economic similarities, playing a key role in fostering neighborhood cohesion and providing emotional and material support(Poortinga, 2012; Ziersch, 2011). Bridging social capital, on the other hand, primarily forms among heterogeneous groups and is more outward-oriented. It is obtained through social organizations, public institutions, religious groups, and other avenues(Daniel P. Aldrich and Michelle A. Meyer, 2015a; Small and Small, 2009), allowing individuals to integrate into a broader society through "weak ties"(Granovetter, 1973). It is a key factor in creating social cohesion(Poortinga, 2012). Linking social capital exhibits more "cross-cutting" characteristics, representing the connections between individuals and groups(Ziersch, 2011), or the connections between grassroots and higher-level formal organizations. This enables grassroots communities to access more extensive and influential support(Zhai and Ng, 2013).

2.4. The Role of Social Infrastructure and Approaches to Addressing Shrinkage

2.4.1. The Role of Social Infrastructure in Shrinkage Cities

Social infrastructure serves as a spatial domain that allows the development of social capital and functions as a "medium." These physical spaces, institutions, organizations, and groups shape daily interactions and establish social connections, thereby determining the level of social capital(Hartt et al., n.d.). Conversely, social capital plays a crucial role in supporting and sustaining social infrastructure and larger community development(Binqing Zhai and Mee Kam Ng, 2013). Existing research indicates that social infrastructure and its social capital play a critical role in addressing community decline, lack of resilience, enhancing community health and well-being, and safeguarding the interests of vulnerable groups in the face of urban shrinkage.

Specifically, social infrastructure can bring external resource support to communities(Weaver and Holtkamp, 2015a), enhance community resilience and cohesion, and resist or even reverse the decline of physical spaces(Nel et al., n.d.). High-quality social infrastructure that promotes functional diversity and caters to diverse user groups is particularly effective in fostering bonding and linking social capital. The former strengthens social cohesion among social groups, while the latter provides channels for grassroots advocacy, thereby creating resilience beyond traditional physical infrastructure(Kathleen A. Cagney et al., 2016; Sampson et al., 1997).

In the context of urban shrinkage, society faces the realities of an aging population, spatial differentiation, and segregation. Social infrastructure can facilitate the formation of critical social networks, enhance the willingness of older adults to engage in community volunteer services(Andrew E. Scharlach and Amanda J. Lehning, 2013), reduce the likelihood of social isolation among community residents, particularly the elderly(Dan, 2020), and enhance the operational and maintenance capacity of shrinking urban communities. For socially isolated and closed-off disadvantaged communities, providing high-quality public spaces and supportive services not only promotes social inclusion(Andrew E. Scharlach and Amanda J. Lehning, 2013; Foord and Ginsburg, 2004) but also enables the establishment of informal connections within the community around social infrastructure. This can foster temporary collaborative groups to address urban shrinkage and create a social support "safety net"(Ali et al., 2022), thereby generating bottom-up collective strength(Binqing Zhai and Mee Kam Ng, 2013).

2.4.2. Restructuring of responses to shrinkage

During the process of shrinkage, urban social structures are influenced by economic and institutional factors, resulting in characteristics such as population aging and structural imbalances, social network fragmentation, and spatial differentiation and segregation. At the same time, from the scale of the city to the neighborhood and even the building level, varying degrees of decline and aging are observed. This leads to differences in social interaction characteristics within urban spaces, affecting the production processes of social support and social resilience (Figure 5).

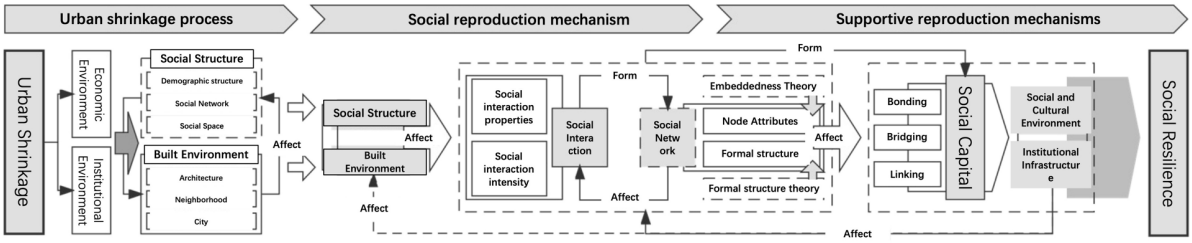


Figure 5 The productive process of social resilience in shrinking cities

The "supportive" nature of social infrastructure is a specific manifestation of its "social" aspect, with the latter being a prerequisite for the former. Supportiveness is primarily demonstrated in the process of disaster response and is expressed as a stock, which can be understood as a form of social resilience. This process involves the transformation of social interaction into a stock of social capital. Social interaction is a necessary condition for the formation of sociality. In the context of urban shrinkage, the built environment of social infrastructure and the social structure of its user population undergo dynamic changes, resulting in variations in social interaction, social networks, and the stock of social capital, which in turn affect the level of urban social resilience.

The built environment in which social infrastructure exists has an impact on the occurrence of social interaction and the formation of social networks(Mario L. Small and Laura Adler, 2019). Geographic proximity increases the likelihood of chance encounters and reduces the perceived distance, thereby lowering the cost of social interaction(Theo Arentze and Harry Timmermans, 2008). Elements surrounding social infrastructure within its affiliated areas, such as restaurants and supermarkets located around squares, can attract people and provide more possibilities for social interaction. At the same time, certain focal elements can also attract crowds. For example, a church, as the center of attention and spiritual focus in a town, becomes a "pivot" for the formation of social interaction(Jaworski, 1998). Additionally, social infrastructure is also influenced by occasional critical events. Factors such as moving to a new residence, starting a new job, or becoming a member of a group increase the probability of repeated encounters and social interaction with others(Theo Arentze and Harry Timmermans, 2008).

The sociality of social infrastructure also depends on the types of social interaction it facilitates(Alan Latham and Jack Layton, 2019). In social infrastructure with specific social characteristics, participants gradually acquire their own specific social attributes and combine them with their inherent economic and social attributes, becoming embedded in individual and local social networks(Steven M. Radil et al., 2010). This "embeddedness" shapes social interactions and networks with different characteristics, forming a structural configuration with different forms of overlap, thereby influencing the categories of social capital. Social capital(Daniel P. Aldrich and Michelle A. Meyer, 2015b), as it participates in the next stage of social interaction, gradually transforms into a stock of resources, including social-cultural environments and institutional infrastructure(Weaver and Holtkamp, 2015b), which then contributes to social resilience.

In summary, the stock of social capital is the product of social interaction within a fixed built environment and social structural background of social infrastructure, reflecting the overall outcomes of sociality and supportiveness. Therefore, measuring the level of social capital can reflect the capacity of social infrastructure in providing public services, which represents the actual benefits for residents' daily lives.

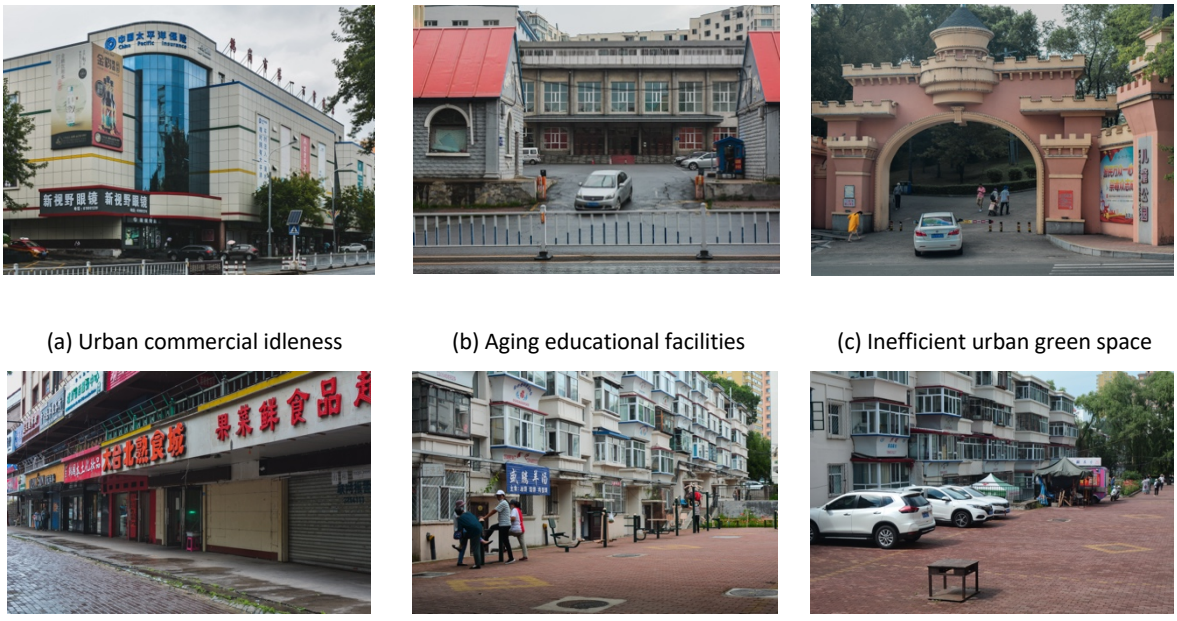
3. Exploring social infrastructure regeneration strategies in shrinking cities

3.1. Typical Case Selection and Research Methodology

By selecting Hegang City as an example, the frequency of social infrastructure utilization (demand side) and the stock of social capital (supply side) within the old urban area are measured separately to explore the balance and patterns of social infrastructure supply and demand. Strategies for enhancing social resilience are proposed. Hegang City is located in Heilongjiang Province in the northeastern part of China and is a typical energy-intensive industrial city with abundant coal resources. After 1950, numerous large-scale coal resources were discovered, leading to the establishment of a large number of resource-based industrial enterprises. The city entered a phase of rapid development, with a significant increase in population and gradual improvement of infrastructure. However, in the early 21st century, as coal resources continued to deplete and with the rapid development of urban clusters such as the Beijing-Tianjin-Hebei, Yangtze River Delta, and Pearl River Delta, the northeastern region generally faced the challenges of population loss and

economic transformation, resulting in a shrinking dilemma. Hegang City thus became a typical case study of a shrinking city due to resource depletion in the northeastern region.

Similar to the characteristics of shrinking cities in the West, against the backdrop of declining population mobility and inefficient aging of public spaces, Hegang City faces the problem of a mismatch between supply and demand for public services, which reduces the operational efficiency of the urban society (Figure 6). In this context, it is necessary to compare and study the corresponding relationship between the demand for existing social infrastructure and the intensity of service supply. Key nodes for nurturing social capital in residents' daily lives need to be identified, guiding updates and investments, and achieving efficient and reasonable enhancement of urban social resilience.



(a) Urban commercial idleness (b) Aging educational facilities (c) Inefficient urban green space

(d) Community business decay (e) Aging of community public space (f) Lack of community green space

Figure 6 Current characteristics of social infrastructure in Hegang City

This study collaborated with the Hegang City government and planning research departments, randomly distributing over 800 questionnaires in communities within the old urban area (Xiangyang District and Gongnong District). The questionnaire data consists of two parts. The first part requires residents to select the most frequently used locations among 26 social infrastructure sites inside and outside the communities. Demand intensity is determined based on standardized frequency data. The second part evaluates social capital at the selected locations, including local social networks, reciprocity and trust, participation in groups or organizations, and cohesion and sense of belonging, comprising a total of 22 questions. Evaluation is conducted using a 1-5 Likert scale method, and the supply intensity level is standardized. The study categorizes social infrastructure into five categories (C-Community, UB-Commercial Facilities, US-Squares, UGS-Urban Green Spaces, EF-Educational and Cultural Facilities), and their supply and demand levels are ranked in descending order for comparison.

3.2. Supply and demand characteristics of social infrastructure services

An analysis of the supply-demand balance of social infrastructure within and outside the community, as well as among different land-use categories, was conducted (Table 1). A comparison revealed that the demand intensity for social infrastructure within the community (such as community vegetable stores, small supermarkets, kindergartens, activity centers, community green spaces, community clinics, etc.)

remained relatively high compared to outside the community. This indicates that the community remains a space used by residents in their daily lives. However, the supply intensity of infrastructure within the community is at a medium-low level, on par with or lower than social infrastructure outside the community. This suggests that the community is no longer the primary site for social interaction and the production of social capital. Social capital has generally flowed out of the community into public spaces beyond its boundaries.

Table 1 Matching relationship between supply and demand of social infrastructure in the old city of Hegang

Type	Number	Social Infrastructure	Demand intensity	Demand ranking	Supply intensity	Supply ranking
C	—	SI in Community	0.73	4	0.63	15
EF	No.24	First Middle School, Fourth Middle School	0.05	19	0.91	3
	No.5	Twenty-one High School	0.05	20	0.86	4
	No.10	Mining Culture Palace	0.01	25	1.00	1
	No.14	Youth Palace	0.01	24	0.79	7
UB	No.4	Biyoute Times Square	1.00	1	0.69	10
	No.7	Hegang First Department Store	0.15	13	0.81	6
	No.2	Biyoute Supermarket (Xinghui Store)	0.33	10	0.68	12
	No.3	Biyoute Supermarket (Hongjun Road Store)	0.73	5	0.49	22
	No.23	Xingshanli Mall	0.21	11	0.57	18
	No.9	Jin Guang Supermarket (Zhenxing Store)	0.48	8	0.42	23
	No.19	Xinhui Plaza	0.10	14	0.59	17
	No.20	Xinhua Bookstore	0.02	23	0.69	11
	No.12	Laozhan Road Commercial	0.05	21	0.63	14
	No.8	Jin Guang Supermarket (Xin Jie Ji Store)	0.06	17	0.51	21
	No.1	Biyoute Supermarket (Liming Store)	0.07	16	0.41	24
	No.21	Xinjieji commercial area	0.07	15	0.36	25
UGS	No.16	Tianshui Lake Park	0.49	7	0.77	8
	No.6	Children's Park	0.81	3	0.60	16
	No.13	Lulin Mountain Park	0.06	18	0.95	2
	No.18	Wuzhishan Park	0.50	6	0.54	20

	No.11	Laoguntang Ruins Park	0.05	22	0.71	9
	No.15	Senhe Park	0.01	26	0.01	26
US	No.25	Zhenxing Square	0.86	2	0.84	5
	No.17	Cultural Square	0.19	12	0.67	13
	No.22	New Century Plaza	0.37	9	0.56	19

Differentiated characteristics of the supply-demand relationship of social infrastructure were studied from the perspective of different land-use categories. A comparison revealed that there is minimal differentiation among educational and cultural facilities, which exhibit greater service supply capacity and smaller usage demand. This is because although educational and cultural facilities serve as the main carriers of social capital formation, their user base is limited and generally consists of homogeneous groups. Within commercial facilities, significant differences were observed. Key nodes such as Biyoute Times Square, Biyoute Supermarket (Hongjun Road branch), and Jin Guang Supermarket (Zhenxing branch) exhibited high demand characteristics. However, the ranking of their service supply capacity did not match the ranking of demand, indicating that although these key nodes are frequently used by residents, they struggle to provide matching social capital. Hegang Yibai and Xinhua Bookstore, as social infrastructure that formed earlier in the Xiangyang District, had a supply capacity that ranked higher relative to demand. This indicates that although these two facilities can provide higher-quality social capital, the actual usage demand is relatively insufficient. Other commercial facilities generally exhibit the characteristics of low supply and high demand, implying that most existing commercial facilities cannot generate a significant amount of social capital within the scope of residents' actual needs. These characteristics indicate that, in the context of shrinking, the formation of social capital is concentrated in a few key nodes, while a large number of commercial facilities are in an "inefficient" supply-demand state, facing a greater risk of decay and aging. Open spaces such as parks and squares in the city's core areas generally exhibit the characteristics of high demand and low supply. Examples include Zhenxing Square, Tianshui Lake Park, and Children's Park. This indicates that crucial open spaces in residents' daily lives do not necessarily provide a level of social capital that matches their usage demands. On the other hand, some open spaces exhibit the characteristics of low demand and high supply, which is related to the nature of the open space itself. For example, Lu Lin Mountain Park carries a significant amount of religious and cultural resources due to the presence of the Putuo Temple, enabling the formation of higher social capital. However, its location in the outskirts and limited accessibility result in insufficient usage demand. Laojuntang Heritage Park, on the other hand, is a newly constructed park and green space. Compared to pre-existing open spaces, it may take some time for residents to recognize and thus has lower usage demand. However, it boasts high environmental quality and historical and cultural attributes, making it a carrier for nurturing social capital.

3.3. Regeneration strategies for social infrastructure

By examining the supply-demand relationship and characteristics of social infrastructure in the typical shrinking city of Hegang, strategies for enhancing social resilience are proposed. The characteristic of mismatched supply and demand is prevalent in the social infrastructure of shrinking cities, with residents' daily lives primarily concentrated in a few key nodes. At the same time, there is still a relatively high demand for social infrastructure services within the community, but the supply is relatively weak, which is related to the widespread decay of the built environment in shrinking city communities. Therefore, in the process of urban renewal, attention should be given to key nodes such as large-scale concentrated commercial areas and open spaces throughout the city. However, issues such as spatial differentiation and social inequality caused by excessive concentration of public services should also be considered. A service

system should be established at the city-regional-community levels to meet the needs of residents within reachable ranges at different levels and enhance the social resilience of shrinking cities.

Critical social infrastructure at the city level (with high and balanced supply-demand levels) should adopt a maintenance and control approach. On one hand, the built environment quality of large-scale commercial areas and open spaces should be maintained, and transportation accessibility should be enhanced to ensure they continue to facilitate social interaction and nurture high-quality social capital. On the other hand, the impact of excessive concentration of individual social infrastructure on other levels of facilities should be considered, which can lead to dispersion of social infrastructure and a decline in vitality and aging phenomena over a larger area.

Social infrastructure at the regional level mainly includes facilities with generally weak supply-demand levels, making it difficult to generate more social capital. They also face the risk of material space aging and decay, making them a focal point of urban renewal. Emphasis should be placed on open spaces with historical and cultural heritage, creating cultural intellectual property (IP), and improving transportation accessibility to make them key places for efficiently nurturing social capital.

Although communities face the risk of social capital loss, the role of community social infrastructure should still be considered. While it may be difficult to reverse population aging and population loss, efforts can be made to involve the elderly population in the operation and management of community social infrastructure, thereby enhancing their supply capacity of social capital.

4. Discussion and conclusion

In the context of shrinkage, urban physical space and social structures face the risk and challenge of decay and aging. Maintaining social resilience and mitigating the impact of shrinkage on urban society becomes a crucial issue. Social infrastructure, which promotes social interaction and nurtures social capital, provides an effective tool in this process. Based on social spatial theory, social infrastructure theory has formed a practical theoretical framework. On one hand, it focuses on the mechanisms of social production, and on the other hand, it transforms sociality into support, namely social capital, which is of significance for addressing real-world problems. As social capital accumulates and continuously participates in the reproduction process of sociality and support, the social-cultural environment and institutional infrastructure of communities gradually establish themselves as intangible assets for maintaining social resilience.

For shrinking cities, the dissolution of social networks in local areas leads to differentiated levels of local social capital, resulting in social resilience inequality. Based on this, the study examines the stock of social capital in typical shrinking cities, such as Hegang, and the matching relationship between actual usage demands of residents. It explores the patterns of supply and demand and proposes strategies for urban renewal and response. The study finds that social capital in shrinking cities is mainly concentrated in a few key nodes, while most nodes struggle to provide social capital supply that matches the demand. At the same time, although community social infrastructure faces the risk of social capital loss, it remains a crucial vehicle for the formation of social capital.

Based on these findings, shrinking cities should consider building a social infrastructure system at three levels: city-regional-community. This includes maintaining key nodes, guiding orderly investment and construction of regional-level social infrastructure, revitalizing the effectiveness of community social infrastructure services, and creating a reservoir of social capital stock. This will facilitate sustainable urban renewal in shrinking cities.

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