Research Paper

Resilience Strategies of Chinese Unit Communities for Addressing Climate Change Risks

A case study of Harbin's historic industrial district

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Abstract

The unit communities have challenges adjusting to the increasing requirements of urban expansion and suffer from ageing and neglected infrastructure that is inadequate for dealing with the growing risks caused by climate change. Community resilience is a collection of abilities that enable communities to effectively predict, adapt to, and recover from multiple hazards. This study combines field research and a literature review to identify the characteristics of unitary communities and to analyse the current problems and climate risk factors at both the objective built environment and subjective initiative levels. Then, we construct a unitary community resilience assessment system from the dimensions of community capital and residents' capacity, based on community resilience theory and previous resilience assessment studies, and use various assignment techniques to determine indicator weights. In addition, this study selected Harbin, a former industrial centre of China, as a representative city and selected 3 unit communities for the questionnaire survey. Finally, this study suggests three key strategies for improving community resilience and coping with climate risks: clarification of tenure matters, incremental renewal of community spaces, and revitalization of the communal character of community residents. Providing strategies and guidance to promote resilient responses to potential risks in unit communities.

Keywords

Community resilience, Post-unit system, Risk management, Resilience evaluation

0. Introduction

The "unit community," as a mode of living space organisation in China during a specific period, played a significant role in the early stages of urban development. It has the historical significance of witnessing the transformation of China's socio-economic system and the academic value of interpreting urban development and transformation. However, the "unit organisation" development model has progressively disintegrated due to the changes in the socio-economic system. The community's operating mechanism as the fundamental social and spatial unit of the city was forced to change during the process of de-embedding it from the unitary organisation. During the process of "re-organisation," the community's social structure and spatial patterns have taken on a more unique identity.

1. Characteristics of unit community and climate risk factors

1.1. The concept of the unit community

In the early days of the founding of the People's Republic of China, China established a vertical linkage control mechanism of "state-unit-individual" and a honeycomb-shaped "unit system" social structure based on the Soviet Union's planned economic system and social development model. With the continuous development of industry, the "units" in cities have continued to expand and have begun to have complex functions such as production, circulation, consumption, education, and management, forming unit communities(Luo et al., 2018, Yuan and Jin, 2021, Beatley and Newman, 2013). After the Reform and Opening-up, China transformed from a planned economy to a socialist market economy, and the unit system gradually disintegrated in the process of resource allocation and social structure change. In the late 20th century, the operation mechanism of urban communities began to be reconstructed, but there are still many "unit system" community spaces in cities, and the "unit" function still exerts its influence and role.

1.2. Characteristics of the unit community

In the process of disembedding from the unit organization, the operating mechanism of the unit community as the basic social space unit of the city has been forced to be reshaped. Its social structure and spatial form need to be reshaped, forming a relatively unique community feature(Aiken, 2012, Kelly et al., 2015, Norris et al., 2008). Different from general communities, its distinctiveness is primarily evident in spatial arrangement, functionality, resident identity, and historical significance, leading to spatial concentration and complexity, functional autonomy and exclusivity, diversity in resident interaction and identity, and unique historical attributes.

The production and residential areas in unit communities are typically in close proximity or interdependent. The communal areas frequently manifest as enclosed courtyards, delineated from exterior environments by walls. The courtyard areas are meticulously designed and systematically organized. The community's buildings generally exhibit an enclosed configuration, with internal amenities organized along a cross-axis, while ancillary services like commerce, education, and healthcare are allocated along this axis. This enables unit personnel to satisfy their need for production, sustenance, and recreation.

Furthermore, the functions of unit communities possess a degree of autonomy. They have autonomous management and building planning authority and are not integrated into the overarching urban planning system, enabling the residents to benefit solely from the available resources(Berkes and Ross, 2013, Meerow et al., 2016, Huang et al., 2022, Liao et al., 2022). Nonetheless, this autonomy also has considerable adverse effects when confronted with inescapable systemic changes. On one hand, following the dissolution of the unit system, the community experienced prolonged management deficiencies, resulting in a swift deterioration of public service facilities; on the other hand, the original residents struggled to adapt to the new community structure in a brief timeframe and exhibit minimal interaction with the newly arrived residents. Simultaneously, certain new residents experienced a deficiency in identification and belonging.

Nonetheless, the unit community, as a distinctive Chinese phenomenon, significantly influenced the initial phases of urban growth. It possesses historical relevance in observing the alterations in China's social structure and has academic worth in elucidating the evolution and transformation of Chinese towns. The prominent Soviet architectural style in many of Northeast China's former industrial centers possesses significant cultural preservation value.

1.3. Climate risk factors of the unit community

Owing to the above-noted features, unit communities experience both intense shock and continued impact from abrupt disasters and potential hazards that much surpass those encountered by ordinary communities. Field surveys of 23 unit communities in Northeast China's former industrial sector have identified various challenges these communities encounter due to the dissolution of the unit system and the reconfiguration of unit service facilities. Examine from the viewpoints of the objective environment and subjective initiative. Objective environment challenges primarily encompass irrational spatial configurations, deteriorating structures, obsolete infrastructure, insufficient service amenities, and disordered transportation networks. Basic surveys of community people reveal that concerns related to subjective initiative mainly encompass inadequate community management, an ageing population, poor educational and economic levels among residents, and a diminished understanding of catastrophe avoidance among the populace(Berkes, 2017, Li et al., 2022, Cumming et al., 2005, Li et al., 2018).

The unit community experiences intense shock due to its enclosed courtyard layout, deteriorating infrastructure, non-compliant auxiliary structures, disordered road networks, and spatial issues including deficiencies in community management and the absence of disaster response systems. When communities encounter abrupt natural disasters, such as floods and severe weather events (rainstorms, snowstorms, hurricanes, etc.), it hampers effective disaster management, including material storage, emergency evacuation, and repair and reconstruction efforts during risk occurrences. Moreover, outdated infrastructure and disorganized design can precipitate secondary disasters, including geological collapses, mob stampedes, and the descent of objects from elevated positions. The aforementioned issues have a continued impact on the unit community. The community, as the fundamental unit of the city, has exacerbated "urban diseases" including traffic congestion, housing shortages, inadequate water supply, environmental pollution, and disorder. Simultaneously, the aging population, declining sense of belonging among residents, and discordant neighborhood relations are susceptible to social risks such as income disparity and elevated crime rates (Figure 1).

Figure 1. Current situation of the unit communities in Northeast China. Source: Photograph by the author.

2. Research on community resilience in response to climate risks

Some researchers have determined that the meaning of community resilience may be broadly categorized into three characteristics based on their examination of current community resilience both domestically and internationally(Li et al., 2018, Bruneau et al., 2003, Carpenter et al., 2001, Carpenter et al., 2012, Fath et al., 2015, Allen and Holling, 2010, Holling, 1973). (1) It is a combination of multiple capabilities such as stability, recovery and adaptation. The community needs to have multiple capabilities such as robustness, redundancy, and rapidity at the same time, and cover the entire process before, during and after the risk occurs; (2) It is a comprehensive capability that is continuously improved during development, covering adaptability and response strategies in the face of various risks, and is a dynamic process of continuous evolution. A resilient community should be able to adapt to external changes in the long term and develop continuously. In the process of responding to risks, it has clear improvement capabilities in each stage from preparation, response, recovery to reconstruction; (3) Community resilience is the goal of sustainable development of the community. The ultimate goal of community resilience is to help the community itself be able to actively respond to sudden disasters and potential risks, and to build a sustainable and resilient living environment through the joint cooperation of residents, governments and non-governmental organizations.

In the same vein, the resilience traits that the community possesses are referred to as the characteristics of community resilience. In particular, it is a compilation of a variety of skills that the community possesses throughout the entire process of confronting hazards. Redundancy, robustness, diversity, adaptability, intelligence, and speed are among the resilience characteristics that have been summarized in existing research. In the context of community risk response, redundancy, resistance, and adaptation assume more significance. Redundancy signifies the surplus of diverse forms of community capital (such as infrastructure, resources, finances, and systems), serving as a precautionary measure prior to risk mitigation, thereby ensuring the community possesses adequate redundant capital to sustain its normal operations during adverse events; resistance pertains to the community's actions and reactions in the face of risks. The community can swiftly react by modifying its operational mechanisms to mitigate the adverse effects of the shock; adaptability encompasses the community's learning and feedback following the shock, enabling it to revert to its pre-shock state and enhance its resilience to unforeseen risks.

3. Construction of resilience assessment model for unit communities

3.1. Screening of community resilience indicators

This study filtered out an indicator library from two dimensions: community capital components and community residents' capacity variables that affect community resilience (Figure 2), based on the risk factors and community resilience characteristics encountered by the "post-unit system" communities. Over 20 specialists in pertinent study domains were chosen to do three rounds of indicator evaluation and selection to derive the final community resilience index(Lu et al., 2023, Folke et al., 2010, Walker and Salt, 2012, Walker et al., 2004). The components of community capital encompass the built environment, material capital, emergency response facilities, community infrastructure, and public service facilities. Meanwhile, the capabilities of community residents include community participation, neighborhood relations, social trust, residents' conditions, and community management. The dimension of community capital components identified four indicators: material space redundancy, service facility redundancy, emergency response facilities, and risk protection facilities, along with 22 associated descriptive indicators. The community resident capacity factor excluded five factors: human capital, risk response ability, social ties, resident engagement, and resident autonomy, together with 13 related descriptive indicators.

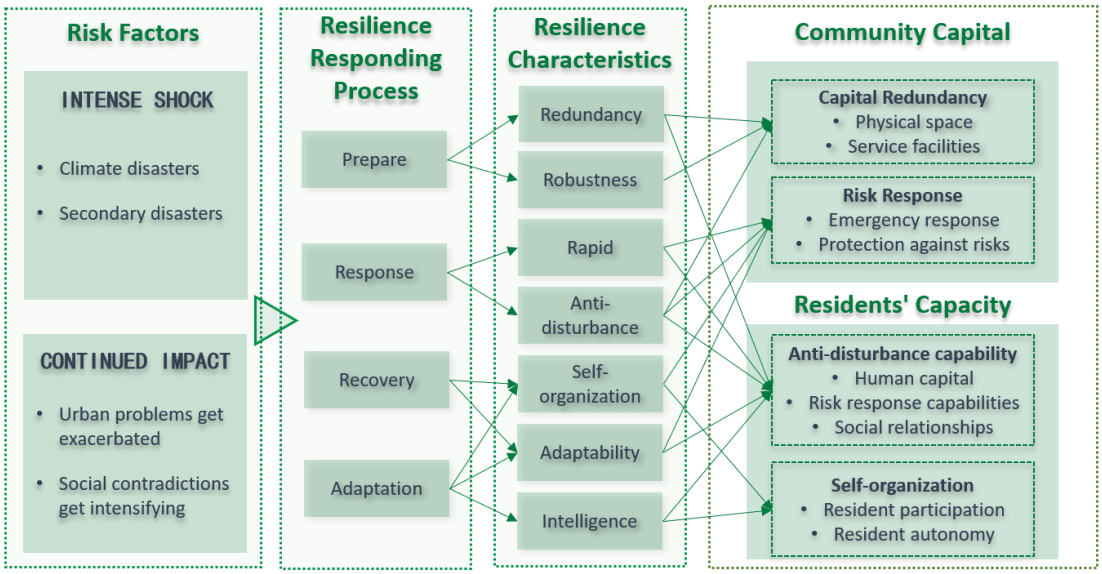


Figure 2. Related factors of community resilience indicators of the unit system.

3.2. Calculation of indicator weights

The study decided to use a combined weighting procedure to establish the indicator weights in order to prevent the evaluation results from being overly subjective. In other words, the evaluation model's hierarchical structure is built using the Delphi technique and the Analytic Hierarchy Process (AHP), and the Analytic Hierarchy Process and the Combinatorial Game Theory Algorithm (AHP-CGT) are then used to determine the final indicator weights(Folke, 2006, Godschalk, 2003, Turner Ii, 2010). The precise methodology of the combined weighting approach grounded in game theory is delineated as follows:

（1）Using x techniques to calculate indicator weights, any basic weight set is $P_k=(P_1,P_2,\cdots,P_x)$, and its linear combination formula is:

$$P = \sum_{k=1}^{x} \alpha_k P_k^T$$

In the formula, α_k is the linear combination coefficient, where $\alpha_k > 0$.

（2）To reduce the difference between P and P_k, the linear combination weight coefficient α_k is tuned. The formula is:

$$\min_g \| \sum_{j=1}^{n} \alpha_j P_k^T - P_g \|_2$$

In the formula, P_g is the basic weight set calculated by the g-th method.

（3）According to the differential properties of the matrix, the linear equations in the following formula are solved to obtain the optimal combination coefficients $\alpha_1,\alpha_2,\cdots,\alpha_x$.

$$\begin{bmatrix} P_1P_1^T & \cdots & P_1P_x^T \\ \vdots & \ddots & \vdots \\ P_xP_1^T & \cdots & P_xP_x^T \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_x \end{bmatrix} = \begin{bmatrix} P_1P_1^T \\ \vdots \\ P_xP_x^T \end{bmatrix}$$

（4）The combination coefficient in the above formula is normalized, and the optimal combination coefficient α_k^* is obtained, which is then substituted into formula 1 to obtain the optimal combination weight P^*. Finally, the community resilience assessment model and indicator weights of the unit system are shown in Table 1.

Table 1. Resilience indicator system for unit communities in response to climate risks.

Dimensions	Primary indicators	Weight	Secondary indicators	Weight	Tertiary indicators	Weight
Community Capital	Capital Redundancy	0.17	Redundancy of physical space	0.58	Number and accessibility of disaster shelters	0.29
					Number of community interaction spaces	0.47
					Quality of buildings	0.24
			Redundancy of service facilities	0.42	Number of public service facilities for daily life	0.6
					Utilization rate of public service facilities for daily life	0.4
	Risk Response Facilities	0.22	Facilities of emergency response	0.74	The completeness of community water supply system	0.21
					The completeness of community power supply system	0.31
					The completeness of community lighting system	0.18
					The completeness of community fire protection system	0.3
			Facilities of protection against risks	0.26	The completeness of community sanitation system	0.05
					The completeness of community heating system	0.47
					The completeness of road system in the community	0.21
					The accessibility of roads around the community	0.27
Residents' Capacity	Anti-disturbance capability of residents	0.32	Human capital	0.18	Education level	0.37
					Health Level	0.21
					Income Level	0.16
					Age structure	0.26
			Risk response capabilities	0.31	Emergency response awareness	0.51
					Coverage ratio of medical Insurance	0.22
					Learning ability and sense of responsibility	0.27
			Social relationships	0.51	Social trust	0.34
					Neighborhood Relations	0.44
					Residents' sense of belonging	0.22
	self-organizing ability of residents	0.29	Resident participation	0.22	Active participation in activities	0.24
					Number of community prestige leaders	0.43
					Number of public discussion platforms	0.33
			Resident autonomy	0.78	Ratio of community managers	0.29
					Number of volunteer rescues	0.71

(Resource: Authors)

4. An empirical study on the resilience assessment of the unit communities in Harbin

4.1. Research area and data processing

Harbin is a typical historical industrial region in Northeast China. The sector has advanced swiftly, resulting in the establishment of numerous work unit communities. The villages have characteristic Soviet-style elements in spatial organization, building configuration, and architectural design. During China's Reforms and Opening-up period, Harbin initiated the establishment of employee communities, incorporating Chinese traits into the original Soviet concept, leading to the emergence of row-style workers' housing. At this point, the distribution of typical unit communities has basically been fixed and has been preserved to this day. At the end of the 20th century, the development of the old industrial base in Northeast China entered a bottleneck period, the management power of public service facilities was transferred, and a large number of new commercial housing communities began to be built. Most communities have a spatial layout model of "demolishing the old and building the new" and "filling in every vacancy". The heterogeneity of the community has increased, and the aging of facilities and the lack of management have gradually evolved into a complex community where low-income, vulnerable groups and migrant workers gather (Figure 3).

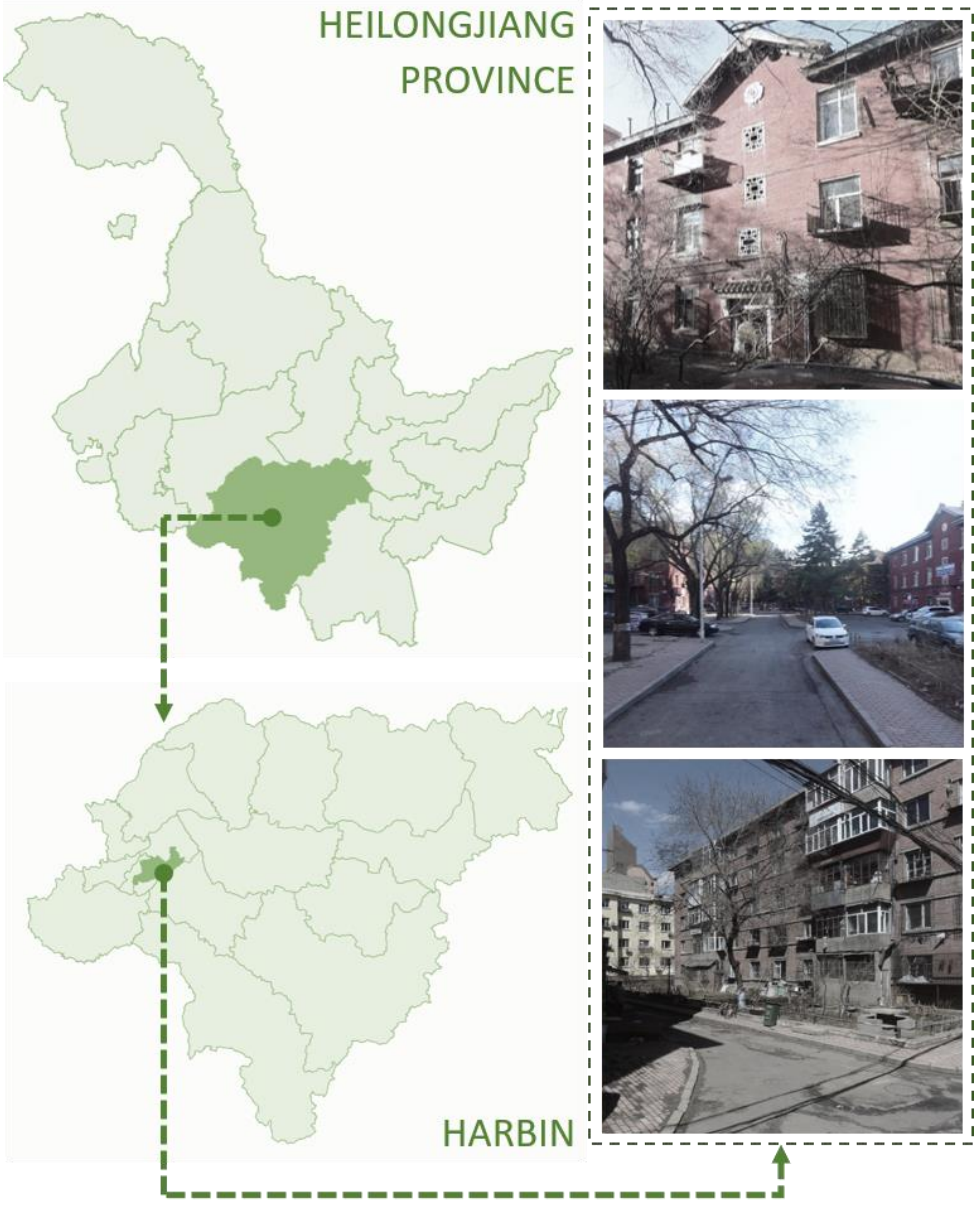
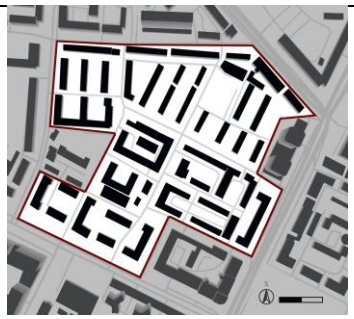
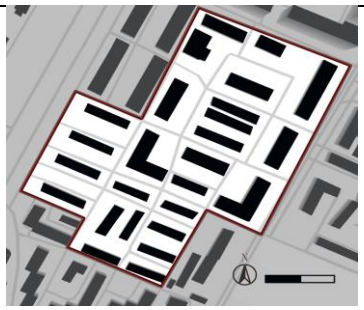


Figure 3. Study area. Source: Drawing and photograph by the author.

This study identified DX, HL, and GLC communities as representative instances of unit communities. The three communities maintain numerous residential structures from the unit era, characterized by traditional courtyard-style elements, while also incorporating supplementary buildings following the unit conversion. Nonetheless, the three towns exhibit substantial differences in the spatial arrangement of public service buildings, border regularity, and courtyard enclosure techniques. The DX community exhibits poor management and unclear boundaries, the HL community demonstrates intermediate management but possesses numerous additional structures, while the GLC community showcases effective management, preserving the enclosed courtyard and spatial scale to the fullest extent. Table 2 presents the floor plans and feature analysis of the three neighborhoods.

Table 2. Analysis of the plan and characteristics of typical unit communities in Harbin

NAME	DX Community	HL Community	GLC Community
PLAN			
CURRENT SITUATION			
SPATIAL ENVIRONMENT	Semi-open community; irregular boundaries; courtyard-style enclosed building layout; chaotic internal road system; no clear public spaces; poor environment.	Semi-open community; relatively regular boundaries; row and enclosed building layout; narrow internal roads; public spaces available; average environment.	The community has clear walls, good privacy; well-defined boundaries; row and semi-enclosed building layouts; a relatively complete internal road system; spacious public spaces; and a slightly better environment.
SERVICES AND FACILITIES	There are a few commercial services within the community, located on the ground floor of the street-facing buildings.	There are many commercial services within the community, distributed throughout the community center.	There are no commercial service facilities within the community.
RESIDENT SITUATION	Residents have a relatively low level of education; income is low; the proportion of employees from the original units is relatively high.	Residents have a relatively low level of education; income is low; the proportion of employees from the original units is relatively high.	Residents have a low level of education; the aging problem is prominent; residents have a high income; the proportion of employees from the original units is relatively high.

The study conducted a questionnaire survey in 3 typical research areas, with 110 questionnaires distributed in each area, and a total of 303 valid questionnaires were collected, with an efficiency of 91.8%. The questionnaire content was divided into three parts based on the above-mentioned community resilience evaluation indicators: personal situation, built environment, and resident capabilities, with a total of 47 questions. The Likert five-point scale method (i.e., a scoring method of 1-5 points from low to high) was used to ask the respondents questions. The collected data was normalized by the min-max standardization method, and the collected data was weighted and calculated with the corresponding hierarchical indicator weights to obtain a comprehensive score. Finally, based on a five-point scale, the "post-unit system"

community resilience assessment results are divided into five categories on a hundred-point scale, namely poor, relatively poor, average, relatively high, and high.

4.2. Results and Analysis of Community Resilience Assessment

From the overall evaluation results, the average resilience of the three communities is 43.3 points, slightly higher than poor and at an average level. Among them, the resilience of the GLC community and the HL community is average, with total scores of 53.2 and 49.6 respectively, while the resilience of the DX community is at a poor level, with a total score of 27.2. It can be seen that community resilience has a strong relationship with the built environment. A good built environment can provide more material redundancy and complete risk response facilities, which is conducive to early preparation and timely response to risks. From the perspective of the dimension results (Figure 4), the community capital scores of the three communities are all lower than the resident ability scores, with an average difference of 12.9 points. The highest scores in both dimensions are in the GLC community, and the lowest scores are in the DX community; from the evaluation results of the four first-level indicators (Figure 5), among the average values of the first-level indicators of the three communities, the residents' anti-disturbance ability is the highest (14.8 points), and the material capital redundancy is the lowest (7 points). Among them, the residents' self-organization ability score of the GLC community is the highest, with 18.8 points, and the material capital redundancy of the DX community is the lowest, with 3.6 points; from the results of the nine second-level indicators (Figure 6), the scores of the second-level indicators of the three communities are basically similar, that is, there are obvious differences between the indicator scores. Among them, the scores of residents' autonomy, social relations and emergency response facilities are relatively high, and the scores of the other six indicators are all low, with the lowest score of residents' participation. In addition, HL community scored higher in service facility redundancy compared with the other two communities; finally, it can be seen from the scatter plot of the three-level indicator scores and weights (Figure 7) that the indicator scores and weights of the three communities show a relatively obvious linear relationship, the two are positively correlated, and most of the coordinate points are concentrated in the low weight-low score area, a small number are scattered in the high weight-low score and high weight-high score areas, and no coordinates fall in the low weight-high score area.

The unit community lacks public spaces with emergency risk avoidance functions and public service facilities to protect residents' daily lives, which results in the community's inability to provide sufficient material space redundancy and service facility redundancy, according to an analysis of the evaluation results of indicators at all levels and the current characteristics of the research area. When a function is harmed during risk-taking, the community operation mechanism cannot mobilize reserve resources to assure normal functioning due to the lack of redundancy. The safety of community members is at risk due to secondary risks including structure collapse, trampling, and material shortages, which are more likely to occur in unit communities that are subject to abrupt disasters like harsh climate. Furthermore, because of ambiguous property rights, disorganized management models, and unclear responsibility allocation in the unit community, private vehicles and mobile vendors seriously occupy road space, large garbage is strewn about randomly, and lighting facilities are dim, with the exception of lifeline facilities like water, electricity, and heating, sanitation, lighting, green space, and other facilities that are essentially unmanaged. It will be impossible to completely safeguard community members' lives and property when climatic hazards arise.

In terms of residents' capabilities, although the study area has a serious lack of material resources, community residents have relatively good social relations and resident autonomy. This may be because most of the residents in the study area are retired employees of their original units, have relatively familiar neighborhood relationships, and have a strong sense of belonging and trust in the community collective. When risks occur, they can actively respond to community calls and help each other among neighbors.

However, community residents lack a public discussion platform, and small repairs and activities in the community are basically organized by residents themselves, lacking funds and guidance from relevant personnel. In addition, due to the serious aging problem of community residents, most retired employees are at a disadvantage in terms of education and health levels, and cannot form redundancy in human capital when facing risks.

In conclusion, the primary issues with the resilience of the unit community are inadequate material capital redundancy, subpar community risk response infrastructure, and low resident resistance to disruption. One crucial issue that has to be resolved and improved is that these issues prevent the community from being completely ready and reacting quickly when faced with dangers. Although residents' ability to self-organize is a sign of some adaptability—that is, they have the potential to recover on their own following a risk—its evaluation score is low and still requires improvement.

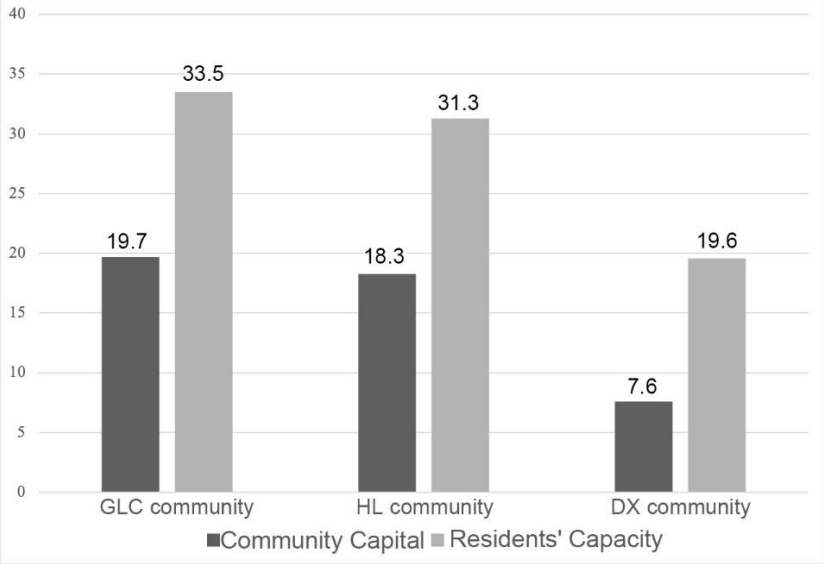


Figure 4. Scores of community resilience dimensions. Source: Drawing by the author.

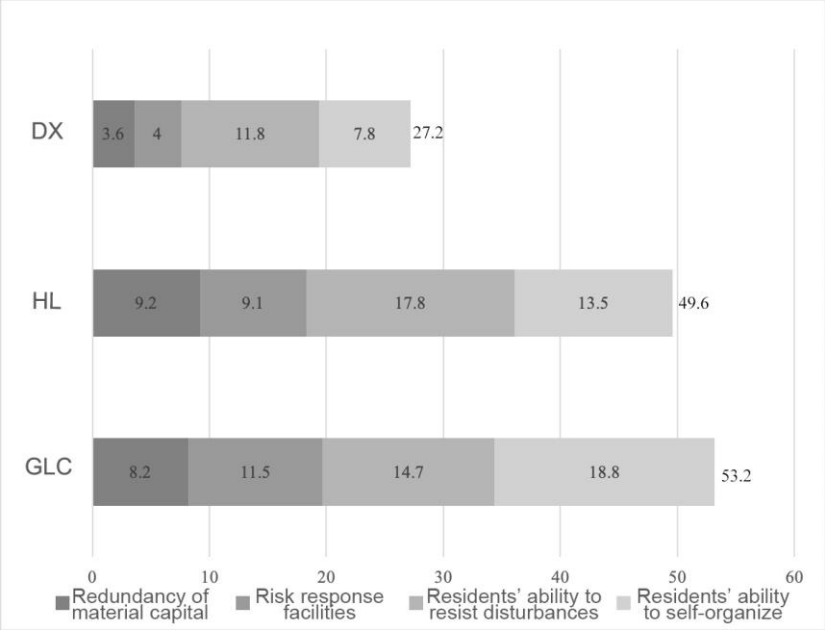


Figure 5. Scores of the first-level indicators of community resilience. Source: Drawing by the author

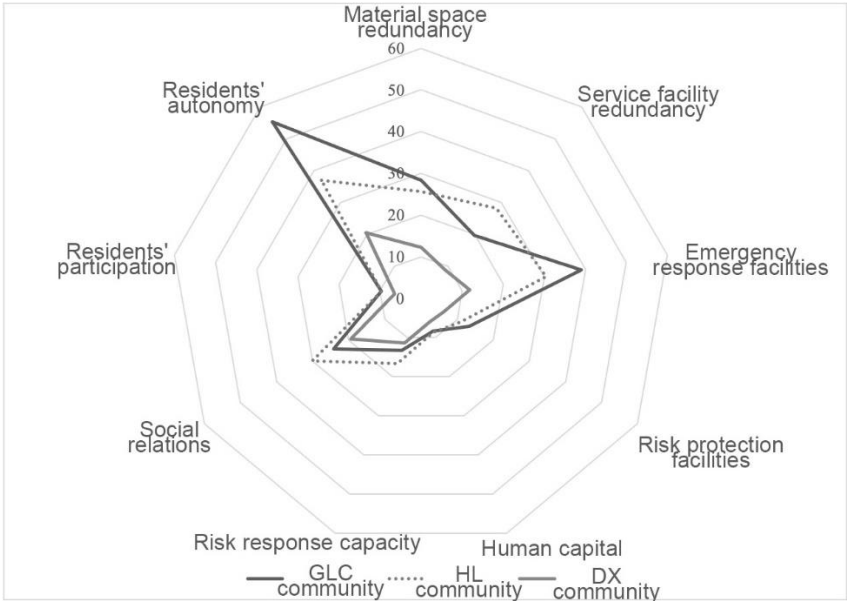


Figure 6. Scores of second-level indicators of community resilience. Source: Drawing by the author.

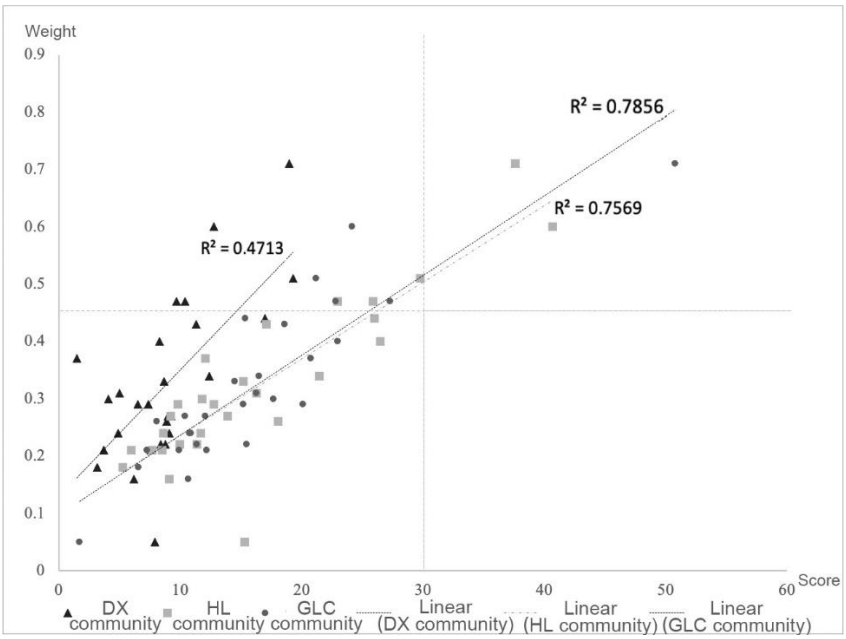


Figure 5. Distribution of scores of the three-level indicators of community resilience. Source: Drawing by the author.

5. Strategies to enhance the resilience of work unit communities under climate risk response goals

5.1. Clarify ownership issues and build a multi-party integrated risk management mechanism

Due to the deepening of the privatization of property rights, the management model that was previously completely state-owned began to change to a management model in which state-owned property rights,

mixed property rights and private property rights are intertwined. This change has led to confusion in property rights, resulting in confusion and lack of management in the unit community. This has resulted in spatial problems such as the failure to repair damaged infrastructure in a timely manner and the inability to update community public service facilities. Therefore, we believes that under the goal of improving resilience, multiple ownership institutions should be integrated to build a community management model of mutual cooperation between "government-enterprise-civilian", establish a policy coordination group, and concurrently serve as a risk response group to jointly decide on community renewal and transformation projects and risk response strategies. While resolving ownership disputes, it is also necessary to broaden the source of community construction funds, reduce the risk of single decision-making, and increase the degree of participation of community residents (Figure 8).

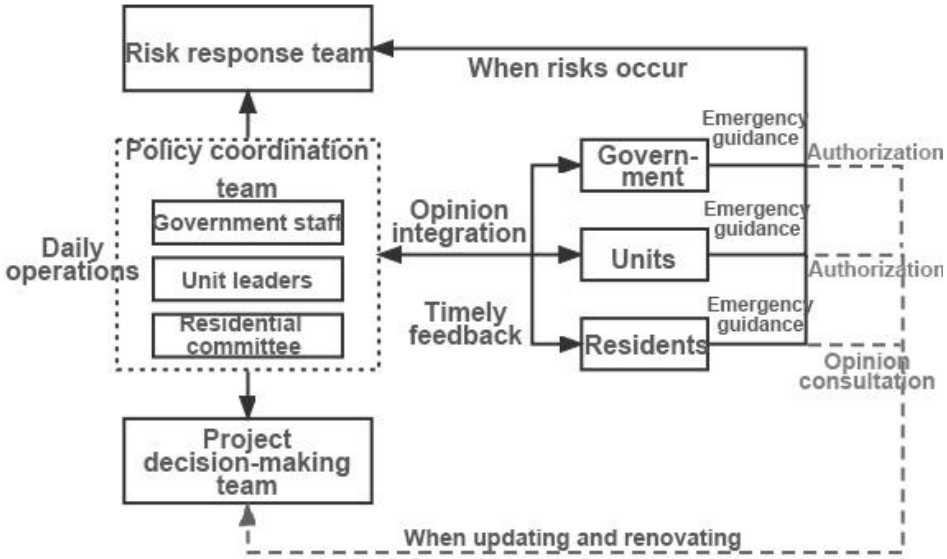


Figure 6. mechanism for multi-party integrated risk management. Source: Drawing by the author.

5.2. Micro-renewal of community space, gradually improving material capital redundancy

In the context of urban stock planning, old communities are turning to continuous repair and renewal, which is more suitable for the unit communities that are left over and have complex ownership issues. In terms of improving the redundancy of community material space, the adjacent group spaces within the community can be integrated, and scattered spaces can be transformed in a "needle-in-slot" manner. The open group space can be used as an emergency shelter when risks occur, and as a community public communication space daily, providing venues for residents' activities, disaster prevention publicity and other behaviors, and playing the aggregation role of public space. In terms of redundancy of service facilities, externally, the unit community can break the courtyard-style space enclosure of the community, open up the public service facility flow lines between the community and the surrounding cities, and realize resource sharing. Internally, corresponding service facilities can be added around the core functional points according to the daily life and activity flow lines of residents. In this way, it is connected with the external urban public service space to form a "point-line-surface" community public service facility space layout, thereby avoiding the problem of resource shortage when facing sudden risks.

5.3. Reconstructing the public nature of community residents and enhancing their adaptive capacity

The collective consciousness, common emotions and behavior patterns of the "unit" still have a profound impact on the community unit employees and residents. This unique behavior and cognition can become an important cornerstone to help the reconstruction of community publicity. The construction of community publicity can enhance the participation of community residents in decision-making and deliberation while enhancing the sense of identity and cohesion of residents, forming a self-organizing structure, thereby improving adaptive capacity. Specifically, through the "bottom-up" "empowerment mobilization" of community residents, that is, granting community residents some administrative functions and powers, community residents can be mobilized to participate extensively in community construction and management activities, forming community non-governmental organizations (NGOs) and non-profit volunteer organizations (NPOs). This kind of community self-organization is more open and flexible, and can enable community residents to "consciously", "spontaneously" and "equally" participate in the negotiation of community renewal projects and the formulation, response and implementation of risk response strategies, build a mutual assistance and sharing risk response platform, and improve the flexible mobilization of various resources in the community, so as to achieve the purpose of improving residents' adaptive capacity.

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