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ABSTRACT

Socially sustainable urban renewal hinges on active public participation, necessitating effective information sharing. Combining Social Network Analysis (SNA) and Ecological Network Analysis (ENA), this study longitudinally investigates how stakeholder information sharing evolves over the project lifecycle of neighborhood rehabilitation and its impacts on resident participation. A representative neighborhood rehabilitation project in Wuhan, China, serves as the study case, with data from 10 interviews, 35 questionnaires, and 3 focus groups. The study suggests that SNA and ENA are complementary and competent in identifying key stakeholders, as well as uncovering undesirable behaviors of manipulation and monopolization, and unhealthy relationships like exploitation and competition. Implementation unit and neighborhood committee emerged as principal information holders, while local media and tenant were least informed. SNA results underscore the central position of neighborhood committee in collecting and disseminating information, demonstrating significant autonomy and control throughout project lifecycle. Conversely, homeowner showed marked dependence and lacked control, particularly in the planning and design phase. ENA findings reveal neighborhood committee's ongoing struggle with information exploitation, eroding its willingness and capacity to share information during the later phases of rehabilitation process. The information exploitation led to a fragile network that further marginalized local media, undermined by dwindling trust and autonomy. Notably, homeowners amplified their discourse power as project progressed, shifting from passive recipients to active decision-makers. Yet, well-informed homeowners monopolized information sharing, deliberately excluding others with conflicting interests, intensifying issues of inequity and opacity. Policy recommendations are provided to counter unhealthy stakeholder dynamics and promote equitable and inclusive public participation in urban renewal initiatives.

1. Introduction

Reflecting a heightened focus on social sustainability, public participation is increasingly recognized as an integral part of urban renewal efforts (Arnstein, 1969; Boyle and Michell, 2020; Enserink and Monnikhof, 2003; Hanzl, 2007; Webler and Tuler, 2006). Following this global trend, China is institutionalizing and normalizing public participation in response to the inequalities, confrontations, and social conflicts emerging in urban renewal initiatives, especially highlighted in its recent endeavors in neighborhood rehabilitation (Hui et al., 2021; Li et al., 2024). Focusing on the aging and dilapidated residential neighborhoods built before 2000, neighborhood rehabilitation in China is the

restoration and enhancement of residential buildings, communal environment, facilities, and systems to "good condition, operation, or capacity" (Zheng et al., 2014). To promote public participation in urban development, the Chinese government revised the *Urban and Rural Planning Law* in 2008, and enacted the *Civil Code of the People's Republic of China* in 2020. These laws confirm the legitimacy of the public's access to information, decision-making and influence over their living environment, and homeowners are entitled to "*possess, use, seek profits from and dispose of the exclusive parts of the building… the common ownership and management over the common areas other than the private areas.*" The *2017 Symposium on the Pilot Programme of Old Neighborhood Rehabilitation* marked the formal integration of the public participation

concept into China's urban renewal initiatives, articulated as "Co-Creation" (Gongtong Dizao) in policy frameworks. Rehabilitation activities provide practical scenarios for applying this concept, encouraging residents to collaborate with public, private, and other social actors to identify problems, allocate resources, make decisions, and share the benefits of these improvements.

Despite policy improvements and the advent of Co-Creation concept have boosted resident participation in China, recent cases show that the participation practices are often clouded by ineffectiveness. One of the main reasons for the ineffective involvement of residents is the problematic sharing of information. This includes underestimating residents' capacity to process information (Leung et al., 2014), providing insufficient, delayed, or selected information (Liu et al., 2018), relying on a one-way information flow that limits public participation to mere informing and consulting (Zheng et al., 2024), and offering few feedback opportunities, alongside a scarcity of channels and platforms for such engagement (Li et al., 2020). These information sharing failures have led to project delays, reversals, loss of public trust (Li et al., 2024), intensified group antagonism and social conflict (Li et al., 2020), undermining the well-intended objectives of these legislative and conceptual reforms.

Similarly, in academia, public participation is recognized as empowering the "have-nots" (Arnstein, 1969), while it is the effective and efficient information sharing that makes it possible (Wilcox, 1994). This viewpoint is grounded in the belief that information sharing is not only a significant aspect of empowerment (Webler and Tuler, 2006), a vital channel of power (Aragonés-Beltrán et al., 2017), but also the prerequisite for residents to exercise their authority (Gudowsky and Bechtold, 2013). As Michel Foucault notes, power can be established and sustained through language, texts, and various forms of communicative practices (Foucault, 2023). Beyond theoretical discussions, empirical research highlights that information asymmetry, alongside insufficient and inefficient feedback, can result in residents' apathy towards participation opportunities (Jia et al., 2021), misconceptions about rehabilitation objectives (Li et al., 2024), diminished trust (Li et al., 2024), and Not in My Backyard (NIMBY) behaviors (Liu et al., 2018), which collectively lead to their reluctance to participation and collaboration. Additionally, from an operational standpoint, scholars investigate the impact of information sources (Zheng et al., 2024), intermediaries (Jia et al., 2021), presentation styles (B. Liu et al., 2023), dissemination channels (Li et al., 2024), and information and communication technologies (ICTs) (Hanzl, 2007) in enhancing participation performances.

While existing studies offer invaluable insights, two significant gaps are apparent. First, these studies depict a dyadic relationship between residents and other stakeholders, treating stakeholders as isolated units that independently exchange information directly with residents. However, real-world observations frequently indicate that stakeholders sharing information are not always the original sources (Weimann, 1982), and indirect transmission and influence are commonly observed (Jia et al., 2021). Recognizing these limitations, Rowley (1997) suggests reimaging construction projects as networks. Social Network Analysis (SNA), a methodology that blends graph theory with mathematical analysis, is introduced and spread in the realms of sociology and management. SNA excels in assessing the flow and intensity of information exchange, whereas it is less adept at discerning the information interdependency among stakeholders and the nature of stakeholders' impact (e.g., beneficial or disruptive). Secondly, most renewal studies oversimplify the renewal process as a homogeneous and static entity. They overlook the dynamic and temporal aspects of information flow, where stakeholder objectives, behaviors, strategies and impacts can substantially evolve (Jia et al., 2021; Weimann, 1982). Despite widespread

appeals from scholars, longitudinal studies that examine the evolution of information sharing remain scarce in urban renewal research. The impacts of changing stakeholder behaviors and their interrelationships on resident participation are yet to be understood.

Given this backdrop, this study introduces an analytical framework integrating Social Network Analysis (SNA) and Ecological Network Analysis (ENA) to longitudinally investigate how stakeholder information sharing affects resident participation in neighborhood rehabilitation. Widely applied in ecosystem research, ENA examines interactions and flows within systems, evaluating how these contribute to system functionality and stability (Fath, 2007; Fath and Patten, 1998). Crucially, it identifies interaction types among stakeholders—reciprocal, exploitative, or competitive—and their impacts on stakeholders' subsequent behaviors (Xiao et al., 2021), thereby addressing gaps in SNA regarding interaction influences.

The study selects the Jiaoweiyuan neighborhood in Wuhan, China, as a case study. Data from 10 interviews, 35 questionnaires, and 3 focus groups provide an in-depth analysis of 1) the types of information stakeholders share; 2) stakeholders' information-sharing behaviors; 3) dependencies and relationships among stakeholders regarding information; 4) the evolution of stakeholder behaviors and relationships through various rehabilitation phases; and 5) the effects of these elements on resident participation. Based on the findings, the study offers policy recommendations aimed at curtailing detrimental stakeholder behaviors and improving information distribution and circulation, which are anticipated to promote equitable and inclusive public participation in urban (re)development.

2. Literature review

2.1. Social network analysis

Rooted in Jacob Moreno's sociogram concept, Social Network Analysis (SNA) maps the connections among individuals in social phenomena, focusing on nodes—such as individuals, groups, organizations, and systems—and their relationships, which can include kinship, respect, and transactions (Snijders, 2001). Advances in algorithms have enhanced the quantitative evaluation of network structures and the roles and influences of actors. The intuitive nature of sociograms and their ability to uncover hidden actors and informal networks have expanded SNA's use across various disciplines. For example, Nita et al. (2022) utilize SNA to examine two-mode networks, highlighting optimal stakeholder involvement in different stages of the Environmental Impact Analysis (EIA) process. In urban redevelopment, Zhuang et al. (2019) demonstrate SNA's utility in analyzing stakeholder interactions within urban regeneration decision-making. Zhou et al. (2022) investigate the evolution of stakeholder value conflicts in construction land reuse projects, while He et al. (2024) analyze social media comments to show how digital platforms can redistribute power in collaborative planning. Despite these advances, research on information sharing networks of urban renewal and their impact on resident participation is still lacking. This study aims to address these gaps.

Sociograms comprise two elements: points and edges. For renewal projects, points signify the stakeholders involved, and edges depict the information flow between pairs of stakeholders. Although sociograms are effective for illustrating small networks, their clarity decreases as more points are added, making it difficult to comprehend complex networks (Haythornthwaite, 1996). To address this, researchers use ordinal or interval data and create equations to quantify the network's overall performance, applying metrics such as network density, centralization, average degree, and average path length for evaluation (Haythornthwaite, 1996; He et al., 2024; Parise, 2007). Similarly, this

study employs *network density* and *average path length* to gauge the overall performance of the information network.

Network density evaluates the ratio of actual connections to the maximum possible connections within a network (Haythornthwaite, 1996). In information networks, a higher network density indicates more pathways for information sharing, suggesting that information sharing among stakeholders is more fluid, frequent, and sufficient. *Average path length* calculates the average distance between all possible pairs of nodes within the network (Parise, 2007). For information networks, a shorter average path length signifies a faster flow and more accurate information as it reduces the number of intermediaries.

Meanwhile, stakeholders' roles and positions in the information network are analyzed through *degree centrality*, *closeness centrality*, and *betweenness centrality*. These three indices offer insights into stakeholders' capabilities to gather and distribute information, the extent to which their information behavior is constrained by other stakeholders, and their control over the information flow, respectively (Freeman, 2002).

Nevertheless, unlike reciprocal relationships such as marriage and contracts, information relationships often display pronounced asymmetry. This asymmetry manifests in directionality—where a communication from node *i* to node *j* does not necessarily trigger a reciprocal response; and in frequency, with node *i* sending frequent communications to node *j*, who may only offer sporadic feedback, and vice versa. The content of information exchange also follows this uneven pattern. Directed and weighted networks thus provide a more appropriate description of the dynamics within information sharing. Moreover, information serves not just as a reflection of power and resources but as a conduit through which individuals or organizations wield influence (Aragonés-Beltrán et al., 2017; Gudowsky and Bechtold, 2013). As such, the source, recipient, direction, and frequency of information sharing carry profound implications for trust, authority, popularity, and leadership (Parise, 2007; Wasserman and Faust, 1994). Consequently, most extant studies employ a directed network approach to analyze information interactions (Caniato et al., 2014; Ferré et al., 2022; Yang et al., 2011). The asymmetric nature of information relationships and established understandings prompt this study to consider information sharing in neighborhood rehabilitation as a weighted directed network.

Degree centrality measures the number of directed edges a node receives or sends in a directed network (Freeman, 2002). Specifically, in-degree indicates a node's capacity to receive information, whereas a high in-degree may denote the node as a critical information recipient, popular, or an opinion leader (Parise, 2007). Conversely, out-degree reflects a node's ability to disseminate information, with a high out-degree suggesting the node acts as a crucial source or distributor of information (Parise, 2007).

Closeness centrality calculates the inverse of the sum of the shortest paths from a node to all others in the network (Rowley, 1997). In directed networks, this metric splits into in-closeness and out-closeness centrality. In-closeness centrality measures how quickly and effectively a node receives information, indicating its accessibility. Conversely, out-closeness centrality assesses how efficiently a node spreads information, reflecting its influence (Wasserman and Faust, 1994). Nodes with high closeness centrality enable rapid and efficient communication, reducing the time and resources needed for information transfer. Moreover, such central nodes enjoy greater autonomy and are less likely to be controlled by other nodes (Rowley, 1997).

Betweenness centrality evaluates the proportion of the shortest paths between all possible pairs of nodes that pass through that node (Freeman, 2002). Nodes with high betweenness centrality act as pivotal "bridges" or "brokers" in controlling, withholding or distorting information flow across the network, promoting communication between different nodes or subgroups (Freeman, 2002).

Notably, stakeholder composition may vary across different phases of the rehabilitation process (Zhuang et al., 2019), leading to varying sizes of information networks. To analyze nodes' relative standings within the same network and track their positional changes throughout different stages of a project, this study uses the equation proposed by Wang et al. (2017) for converting absolute values into comparative values:

$$C'_i = \frac{C_i - Min(C)}{Max(C) - Min(C)} \tag{1}$$

Where C'_i represents the relative centrality of node *i* (applicable to degree, closeness, and betweenness centralities). C_i is the absolute centrality value of the node, with $Max(C)$ and $Min(C)$ denoting the highest and lowest centrality values among the network's nodes, respectively. The formula adjusts centrality to a 0–1 scale, inclusive of 0 and 1, to compare the centrality of node *i* against others in the network. A higher C'_i value indicates a greater centrality relative to other nodes.

2.2. Ecological network analysis

The widespread application of SNA in empirical research has proven its effectiveness in evaluating network efficiency and pinpointing key stakeholders and their influences. However, SNA faces challenges in dissecting the interdependence of stakeholders (e.g., mutualism or exploitation) and the impact of stakeholder interactions on information sharing (e.g., facilitate or inhibit). Additionally, SNA struggles with identifying complex and conflicting stakeholder behaviors. For instance, node *i* actively gathers and delivers information while refusing to share knowledge with node *j* due to conflicting interests. This contradictory behavior leaves *j* marginalized from rehabilitation activities. SNA highlights *i*'s pivotal role in the information network, but it falls short in addressing its exclusionary impact on *j*. Although infrequently explored in urban studies, the effects of interactions on system functioning are widely discussed in ecosystem studies through the lens of Ecological Network Analysis (Fath, 2007; Fath and Patten, 1999).

Introduced by Hannon (1973), Ecological Network Analysis (ENA) is a powerful tool for investigating species interactions, energy flows, and material cycles within ecosystems, focusing on how these elements contribute to ecosystem function and stability. Throughout the neighborhood rehabilitation process, stakeholders are segmented into subgroups based on characteristics such as social division of labor, class, interest preferences, and educational levels. Information circulates within these subgroups, fostering consensus-building and competition or cooperation among groups. Moreover, since neighborhood rehabilitation projects involve artificial and natural resources and require substantial capital, they can be considered vital subsystems of broader ecological-economic systems. In this sense, ENA has the potential to complement SNA in addressing the latter's oversight of interaction influences.

Network utility analysis (NUA) in the ENA is employed to dissect stakeholders' information interdependency and its impact on information sharing. Specifically, direct utility matrix *D* and integral utility matrix *U* are used to quantify the impacts of interactions among stakeholders (Fath and Patten, 1999). *D* captures the strength of the direct utility of node *i* to *j*, denoted D_{ij}. *U* encompasses both direct and indirect relationships, illustrating the overall effect of these interactions (Fath, 2007):

$$D = [d_{ij}] = \left[\frac{f_{ij} - f_{ji}}{T_i}\right] \tag{2}$$

$$U = (I - D)^{-1} = I + D^1 + D^2 + \ldots + D^n + \ldots \tag{3}$$

Where f_{ij} is an information flow from stakeholder j to stakeholder i and T_i is the sum of information flows into or out of stakeholder i. I is D^0, stands for the initial flows. D^1 denotes the direct utility relation and D^n stands for the direct utility relation realized by extending flow pathways.

The sign of D_{ij} (Sign$D$) and U_{ij} values (Sign$U$)—positive for beneficial and negative for harmful interactions—helps categorize stakeholder interrelationships into four types (Fath, 2007):

1) Mutualism $(+, +)$, where both stakeholder i and stakeholder j benefit from their interaction. This type of relationship fosters the production and steady flow of information, which is crucial for the long-term viability of resident participation.
2) Exploitation $(+, -)$ occurs when stakeholder i benefits more from the interaction than it contributes to stakeholder j. Conversely, Exploited $(-, +)$, where stakeholder j benefits at the expense of i. Such interactions may offer short-term advantages to the exploiting party but undermine long-term collaboration by reducing the exploited group's willingness and ability to share valuable information.
3) Neutralism $(0,0)$, where both i and j are unaffected by, or achieve a balance of input and out in, their interaction.
4) Competitive $(-, -)$ describes a detrimental interaction where both stakeholders i and j are negatively impacted. This competitive stance hinders the production and sharing of information, severely limiting the potential for sustained participation initiatives.

The analysis of stakeholder interactions on information sharing is conducted using the mutualism index (MI) and synergism index (SI) (Fath and Patten, 1999). MI is the ratio of the number of positive and the number of negative relationships in U, while SI calculates the total utility values of all relationships in the network (Fath and Patten, 1998):

$$MI = \frac{SignU(+)}{SignU(-)} \tag{4}$$

$$SI = \sum_{j=1}^{n} \sum_{i=1}^{n} u_{ij} \tag{5}$$

$MI \geq 1$ indicates that there are more beneficial than unfavorable relationships in the system. Most stakeholders benefit from information sharing. $SI > 0$ implies that the information network is synergistic, i.e., information sharing among stakeholders can accomplish more than stakeholders working alone.

Integrating these indices with SNA ones, the final analytical framework for this study is introduced. As depicted in Fig. 2.1, the analytical framework investigates stakeholder information sharing, its impacts on resident participation, and, more importantly, how these elements evolve across various phases of the neighborhood rehabilitation project lifecycle.

2.3. Neighborhood rehabilitation and resident participation in China – stakeholders, phases and information

China's urbanization rate had surged from 17.92 % in 1978 to 65.22 % in 2022. This rapid yet uneven urbanization presents considerable challenges, especially in residential areas established during the initial stages of urban expansion. Characterized by subpar construction and lack of daily maintenance, these early-stage neighborhoods often suffer from decaying structures, disorganized communal areas, non-operational facilities, and outdated infrastructure (SC, 2020a). The exodus of more affluent and educated homeowners, coupled with an influx of renters, has exacerbated insecurity, exclusion, and alienation among remaining inhabitants (Li et al., 2024). Currently, around 17,000 aging neighborhoods exist throughout China, negatively impacting the living conditions of over 100 million people (SC, 2020c).

In response, the *Central Urban Work Conference 2015* underscored the critical need for neighborhood rehabilitation, advocating for an approach that transcends mere energy efficiency to embrace a more holistic paradigm. This vision gained significant traction in 2017, when the Ministry of Housing and Urban-Rural Development (MOHURD) launched pilot projects in 15 cities. By 2019, with an enhanced understanding of the challenges presented by aging neighborhoods and their residents, MOHURD, in collaboration with the National Development and Reform Commission (NDRC) and the Ministry of Finance (MoF), issued the *Notice of 2019 Neighborhood Rehabilitation* to institutionalize neighborhood rehabilitation efforts formally. These initiatives paved the way for subsequent policies, regulations, initiatives and technical standards[1] that not only define the rehabilitation process in detail but also clarify the roles and responsibilities of involved actors. These actors are the stakeholders of neighborhood rehabilitation who possess the information, resources, and competencies necessary to conduct rehabilitation activities or halt unnecessary actions, including resident participation (Freeman, 1984).

Recognizing neighborhood rehabilitation's significant political and social advantages, the government finances and spearheads these initiatives through a top-down approach (SC, 2020a). The central government formulates overarching policies, which provincial and municipal authorities customize to address local needs, secure funding, and define specific objectives. District governments coordinate, provide approvals, manage monitoring and evaluation, and select key project personnel such as designers, constructors, and consultants. At the more localized level, the subdistrict administrative office oversees daily operations, handles emergencies, and facilitates cooperation in rehabilitation (SC, 2020a).

Yet, promoting participatory neighborhood rehabilitation would be challenging for the subdistrict office without the assistance of the neighborhood committee (*Juweihui*) (Li et al., 2024). In China, the neighborhood committee is a grassroots organization encouraging self-management, self-education, and self-service among residents. Committee members, often non-local residents, are elected by residents while are supported and empowered by the local government. The significance of neighborhood committees in fostering community engagement has been highlighted, especially after the COVID-19 pandemic (Z. Liu et al., 2023). They act as liaisons for the government, disseminating laws and policies to residents. They also play the pivotal role of family head, engaging in resident education, conflict resolution, and feedback collection (SC, 2020a).

Other stakeholders involved in neighborhood rehabilitation include implementation units, designers, constructors and property management companies, tasked with coordination, design, construction, and ongoing maintenance, respectively (Li et al., 2024). Meanwhile, some projects engage enterprises, scholars, and non-governmental organizations (NGOs) to foster innovative resident participation in rehabilitation (SC, 2020a). Prominent examples include the co-governance and sharing program in Wuhan (Luo et al., 2020), the urban regeneration engine model in Beijing (Shen et al., 2021), and the community planner scheme in Guangzhou (Zhao et al., 2023). Additionally, the rise of ICTs and social media has amplified the role of media in rehabilitation efforts (He et al., 2024). These platforms enable quick dissemination of policies and success stories, and provide a venue for residents to voice opinions or dissent (SC, 2020a).

For residents, unlike redevelopment projects that require intensive, one-time involvement, neighborhood rehabilitation emphasizes continuous participation throughout the project's lifecycle (SC, 2020a). Residents are engaged to determine (SC, 2020a, 2020b): 1) the necessity of rehabilitation; 2) rehabilitation scope and content; 3) design plans and strategies; 4) the construction schedule; and 5) management mode and responsible parties. In turn, these critical decision points segment the project lifecycle into five iterative phases (MOHURD, 2021): **Phase I**

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[1] For a detailed review of policies related to neighborhood rehabilitation and resident participation in China, see Li, Zhuang et al. (2024).
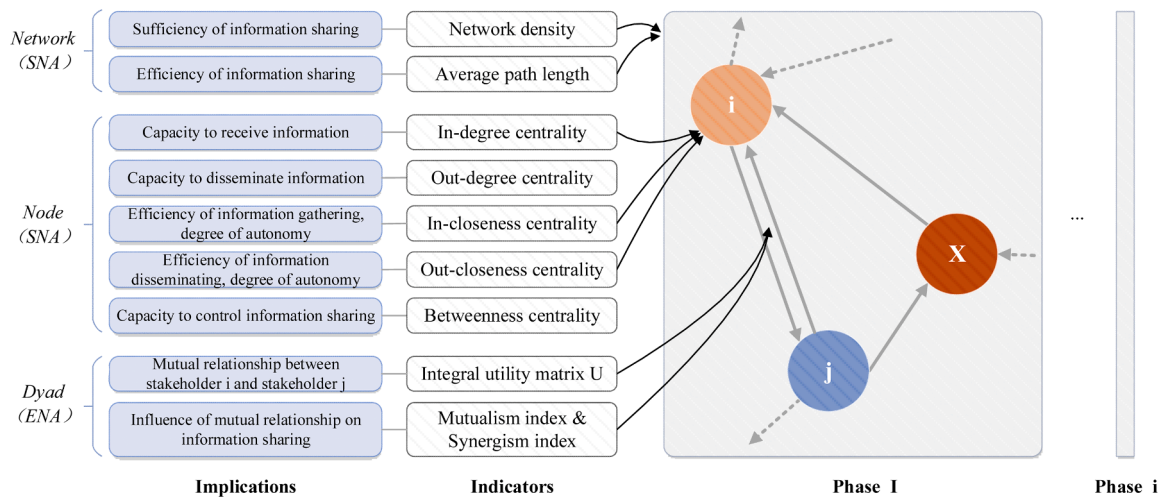
Fig. 2.1. Analytical framework.

- Intention and Setup; Phase II - Mapping and Assessment; Phase III - Planning and Design; Phase IV - Construction and Acceptance; and **Phase V - Operation and Maintenance**.

Integrating government documents with scholars' empirical observations, this study identifies nine types of information circulated among stakeholders during neighborhood rehabilitation. Their implications for resident participation are detailed in Table 2.1.

3. Methodology

3.1. Case study area

Located in central Wuhan, the study case, Jiaoweiyuan neighborhood, was developed in the 1980s. It consists of privatized public housing, housing 481 households with an ownership-to-tenancy ratio of 7:3. The neighborhood recently underwent a government-led rehabilitation, adhering to a recommended five-phase process. The 20-month project commenced in December 2019 but faced delays from February to May 2020 due to COVID-19 lockdowns, resuming thereafter and concluding in December 2021. This round of rehabilitation involved 53 tasks aimed at enhancing infrastructure, road and parking facilities, fire and safety measures, building structure and envelope, as well as communal spaces and services.

Jiaoweiyuan rehabilitation project was selected as the study case due to its emphasis on resident participation and information sharing, with the latter regarded as the primary strategy for fostering community engagement. This emphasis ensured detailed documentation of participatory and communication activities throughout the project lifecycle. Also, project-relevant actors showed interest in enhancing information sharing and enthusiasm for participating in this research. Additional rationales for choosing Jiaoweiyuan include the diverse and accessible data, along with the project's representativeness and typicality of neighborhood rehabilitation projects in Wuhan, China.

3.2. Data collection and analysis

Following a conventional stakeholder analysis methodology (Yang et al., 2011), this research was structured in three phases: 1) identifying stakeholders, 2) documenting stakeholders' relationships, and 3)

evaluating these relationships. Additionally, employing network analysis, this study concentrated on the complete network within the Jiaoweiyuan project, aiming to investigate all *stakeholders* and their potential *relationships*. In this context, *stakeholders* refer to organizations comprising individuals with similar responsibilities and interests in the project who can affect or are affected by the project (Freeman, 1984). Meanwhile, *relationships* denote the deliberate information exchanges between stakeholders to advance the project.

Data collection began with desk research of government documents, project logs and newspaper articles, to develop an initial list of organizations (stakeholders) that affected or were affected by Jiaoweiyuan rehabilitation project. Semi-structured interviews followed to validate and finalize the stakeholder list. Utilizing snowball sampling, 10 respondents were approached from April to May 2022. These included 3 government officials, 2 community workers, 2 designers, 1 contractor, and 2 residents, all of whom were directly involved in the Jiaoweiyuan rehabilitation project. Through these interviews, 31 stakeholders were identified and cataloged in Table 3.1, comprising 28 non-resident stakeholders and 3 resident stakeholders.

This study implemented distinct data collection methods for non-resident and resident stakeholders. Between May and October 2022, in-person surveys were conducted with leaders or management-level personnel of non-resident organizations, yielding 35 valid questionnaires encompassing all 28 identified non-resident stakeholders (Table 3.1). Considering the complex and detailed nature of the questionnaire, the in-person approach ensured respondents fully comprehended the research context and queries, thus increasing the accuracy and completeness of their responses (Marta-Pedroso et al., 2007). This approach also allowed researchers to perform timely verifications and follow-up interviews. For resident stakeholders, data collection was carried out via focus groups. Considering the large and diverse nature of the population, individual inquiries would not have sufficiently captured all viewpoints. In converse, focus groups facilitat an interplay of opinions, feelings, and experiences, culminating in a consensus rather than isolated experiences (Leung et al., 2014; Yang et al., 2011). Thus, the results from focus groups more likely reflect residents' average perceptions of information sharing. The structuring and execution of focus groups followed the methodologies proposed by Leung et al. (2014) to circumvent potential procedural issues. Given that the suitable

Table 2.1

Information shared among stakeholders during neighborhood rehabilitation.

Types of information	Implications for resident participation	Reference
Policy and regulations	- Laws, policies, objectives and evaluation criteria regarding rehabilitation and resident participation.	(Jia et al., 2021; SC, 2020a)
Administrative arrangement	- Administrative structure, institutions and process. - Responsibilities and authority of institutions.	(Li et al., 2024; MOHURD, 2021)
Project information	- Usage, operation and maintenance of buildings, communal environment, infrastructure and services. - Project schedule, decisions and progress. - Problems and issues, their causes and relevant entities.	(Jia et al., 2021; SC, 2020a)
Indigenous knowledge and experience	- The knowledge, (in)material resources, trust, relational and position capital possessed by neighborhood residents. - Residents' socio-demographic characteristics. - Residents' attitude, awareness, experience and skills regarding rehabilitation and resident participation.	(Liu et al., 2018; SC, 2020a; Webler et al., 2001)
Objectives and concerns	- Capacities and attitudes of group members and other stakeholder groups. - Stakeholders' interests, needs, requirements and constraints to rehabilitation and resident participation. - Stakeholders' comments, suggestions and feedback.	(Enserink and Monnikhof, 2003; Gudowsky and Bechtold, 2013; MOHURD, 2021; SC, 2020a)
Design information	- Design theories, strategies, methods and standards. - Mapping and drawing knowledge, such as presentation, diagramming and technical drawing. - Meaning and implications of design drawings.	(Liu et al., 2018; Webler et al., 2001)
Construction information	- Characteristics, applicability, advantages and constraints of rehabilitation strategies. - Construction methods and techniques, impacts and solutions.	(Jia et al., 2021; MOHURD, 2021)
Management information	- Experience, expertise and knowledge in managing information, risk, crisis, process, stakeholders, and technology during rehabilitation.	(Li et al., 2024)
Participation information	- Participation opportunities. - Benefits, limitations and costs of resident participation. - Knowledge concerning resident participation design and implementation, including process, approaches, channels, techniques, depth and breadth of resident participation.	(Boyle and Michell, 2020; Li et al., 2024; MOHURD, 2021; SC, 2020a)

group size ranges from 6 to 12 participants, three focus groups were organized, covering the 3 identified resident stakeholders: one with 8 general population representatives, one with 10 neighborhood home-owners, and another with 6 neighborhood tenants. All in-person survey sessions and focus group discussions were conducted with participants'

consent and were recorded and transcribed.

During the survey sessions and focus group discussions, participants addressed questions concerning their familiarity with types of information and their information sharing experiences (network questions). The survey protocol is detailed in Appendix A and has received approval from the Human Research Ethics Committee at the authors' institution. Initially, participants used a five-point Likert scale (1 - No knowledge, 2 - Poor knowledge, 3 - Average knowledge, 4 - Good knowledge, 5 - High knowledge) to rate their familiarity with nine types of information encountered during the Jiaoweiyuan rehabilitation (Table 2.1, Question 1). Following this, they responded to network questions, using questions and scales adapted from Yang et al. (2011). Participants were first presented with a flowchart of the Jiaoweiyuan rehabilitation process and the stakeholder list (Table 3.1). Set against a specific phase of the rehabilitation process, they were then asked to identify all organizations with whom they had exchanged information (Q2), specify the direction of the information exchange (Q3, with P – provide, R – receive, and RP – in both ways), and indicate the frequency of these exchanges (Q4) using a five-point Likert scale (1 – Only once, 2 – Two or three times, 3 – Multiple times, but not weekly, 4 – Once a week, 5 – Several times a week). Q2, Q3, and Q4 were repeated five times to track participants' information exchange actions throughout the different phases of the project.

The qualitative data for this study, including recordings, transcripts, project logs, reports, and newspaper articles, were collated and analyzed using the ATLAS.ti software. Two of the authors analyzed the data employing a two-step deductive content analysis approach. Specifically, a codebook was first developed that detailed six themes: phases of information sharing, partners, direction, content, intensity, challenges, and countermeasures. Data was then coded according to these pre-determined themes. Network data acquired from surveys and focus groups was organized into five asymmetric valued matrices, each corresponding to one of the five project phases. SNA was performed using

Table 3.1

Stakeholders(organizations) in Jiaoweiyuan rehabilitation project.

No.	Stakeholder
	Non-resident stakeholders
1	Municipal Bureau of Housing Management
2	Municipal Bureau of Finance
3	Municipal Bureau Natural Resources and Planning
4	District Bureau of Housing Management
5	District Bureau of Finance
6	District Branch of Natural Resources and Planning Bureau
7	District Bureau of Administration and Approval
8	Commission of Development and Reform of the District
9	District Bureau of Water and Lakes
10	District Bureau of Parks and Landscaping
11	Fire Rescue Brigade of the District
12	District Bureau of Public Security
13	Subdistrict Administrative Office
14	Subdistrict Branch of Urban Management and Law Enforcement
15	Neighborhood Committee
16	Community worker
17	Self-governance Group
18	Planner
19	Architect
20	Surveyor
21	Implementation unit
22	Constructor
23	Original property owner (work unit)
24	Property management company
25	Law firm
26	Non-government organization (NGO)
27	Local newspaper
28	Research institute
	Resident stakeholders
29	Homeowner
30	Tenant
31	The public

Legend

1 No knowledge
2 Poor knowledge
3 Average knowledge
4 Good knowledge
5 High knowledge

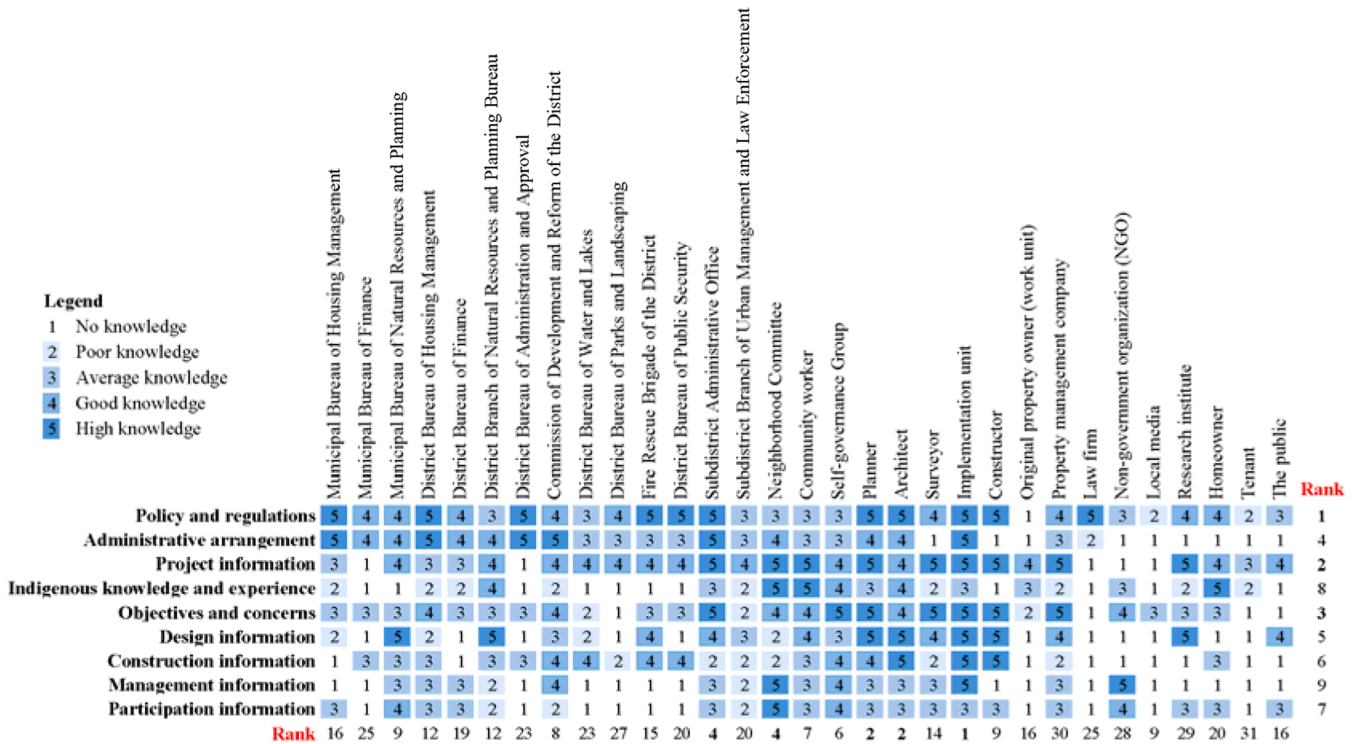| Information type	Municipal Bureau of Housing Management	Municipal Bureau of Finance	Municipal Bureau of Natural Resources and Planning	District Bureau of Housing Management	District Bureau of Finance	District Branch of Natural Resources and Planning Bureau	District Bureau of Administration and Approval	Commission of Development and Reform of the District	District Bureau of Water and Lakes	District Bureau of Parks and Landscaping	Fire Rescue Brigade of the District	District Bureau of Public Security	Subdistrict Administrative Office	Subdistrict Branch of Urban Management and Law Enforcement	Neighborhood Committee	Community worker	Self-governance Group	Planner	Architect	Surveyor	Implementation unit	Constructor	Original property owner (work unit)	Property management company	Law firm	Non-government organization (NGO)	Local media	Research institute	Homeowner	Tenant	The public	Rank
Policy and regulations	5	4	4	5	4	3	5	4	3	4	5	5	5	3	3	3	3	5	5	4	5	5	1	4	5	3	2	4	4	2	3	1
Administrative arrangement	5	4	4	5	4	4	5	5	3	3	3	3	5	3	4	3	4	4	1	5	1	1	3	2	1	1	1	1	1	1	1	4
Project information	3	1	4	3	3	4	1	4	4	4	4	5	4	5	5	4	5	4	5	5	4	5	1	1		5	4	3	4		2	2
Indigenous knowledge and experience	2	1	2	2	4	1	2	1	1	1	3	2	5	5	4	3	4	2	3	1	3	2	1	3	1	2	5	2	1			8
Objectives and concerns	3	3	3	4	3	3	3	4	2	1	3	3	5	2	4	4	5	5	4	5	5	5	2	5	1	4	3	3	3	1	1	3
Design information	2	1	5	2	1	5	1	3	2	1	4	1	4	3	2	4	3	5	5	4	5	5	1	1	1	1	5	1	1	4		5
Construction information	1	3	3	3	1	3	3	4	4	2	4	4	2	2	2	3	4	4	5	2	5	5	1	2	1	1	1	1	3	1	1	6
Management information	1	1	3	3	3	2	1	4	1	1	1	1	3	2	5	3	4	3	3	3	5	1	1	3	1	5	1	1	1	1	1	9
Participation information	3	1	4	3	3	2	1	2	1	1	1	1	3	2	5	3	4	3	3	3	3	3	1	3	1	4	1	3	3	1	3	7
Rank	16	25	9	12	19	12	23	8	23	27	15	20	4	20	4	7	6	2	2	14	1	9	16	30	25	28	9	29	20	31	16	

Fig. 4.1. Stakeholders' familiarity with various types of information.

Ucinet 6 software (Borgatti et al., 2002), with visualization facilitated by Netdraw software. ENA was executed in Python using the NumPy library and was visualized in Excel.

4. Results

4.1. Stakeholders' levels familiarity of information

As shown in Fig. 4.1, most stakeholders of Jiaoweiyuan project were well-acknowledged in *Laws and Regulations*, with only three demonstrating limited knowledge. *Project Information* is the second best-understood category, with 26 stakeholders showing an average knowledge or higher (score≥3). However, there is a noticeable gap in *Indigenous Knowledge and Expertise*, followed by *Management Information* and *Participation Information*. 20, 15 and 10 stakeholders, respectively, indicating poor or no knowledge.

Implementing unit emerges as the most informed stakeholder, except in *Project Information* and *Participation Information*. Planner, Architect, and Neighborhood Committee also show high knowledge levels. Conversely, Local media, Tenant, and Law firm rank lowest in familiarity of most information types, aside from *Objectives and Concerns*.

4.2. Evolution of information sharing and influence on resident participation

4.2.1. Overall network

Table 4.1 shows that the network density remained below 0.3,

Table 4.1
Density and average path length of information network of Jiaoweiyuan rehabilitation.

	Phase I	Phase II	Phase III	Phase IV	Phase V
Density	0.212	0.266	0.262	0.239	0.286
Average path length	2.120	1.894	1.911	2.028	2.052

indicating limited and sporadic information flow among stakeholders throughout the project's lifecycle. The highest density (0.286) occurred in Phase V. The network's average path length remained close to 2 throughout the project. Phases II and III are lower than 2, indicating that in Jiaoweiyuan rehabilitation, stakeholders communicated directly or through just one intermediary to other stakeholders. The network was relatively coherent, facilitating the rapid and accurate dissemination of information among the stakeholders.

4.2.2. Influence of key stakeholders

Integrating Fig. 4.2 with centrality data (Appendix B) sheds light on seven stakeholders significantly impacting information sharing of Jiaoweiyuan rehabilitation: District bureau of housing management, Sub-district administrative office, Neighborhood committee, Architect, Implementation unit, Local media and Homeowner. They participated in various phases of the rehabilitation process and occupied central positions within the information network. Their significance was further emphasized by frequent mentions and discussions during interviews. As a result, this research focuses on these seven stakeholders, examining their positions in and influence on the information network and the evolution of their impacts.

As shown in Fig. 4.3, District bureau of housing management held a prominent position during Phase I. It scored 1 on all five centrality indexes, indicating its superior centrality compared to the other 20 stakeholders. The housing bureau served as both the primary source and recipient of information, exerting significant control over the partner, pathway, and content while maintaining considerable independence. However, its centrality declined as the project progressed. Starting from Phase II, the neighborhood committee assumed a more prominent role in information circulation. Local media took over as the primary information controller in Phase V.

The centrality of the Sub-district administrative office peaked in Phase III. Although the office's capacity to distribute and receive information increased and decreased, it remained relatively low
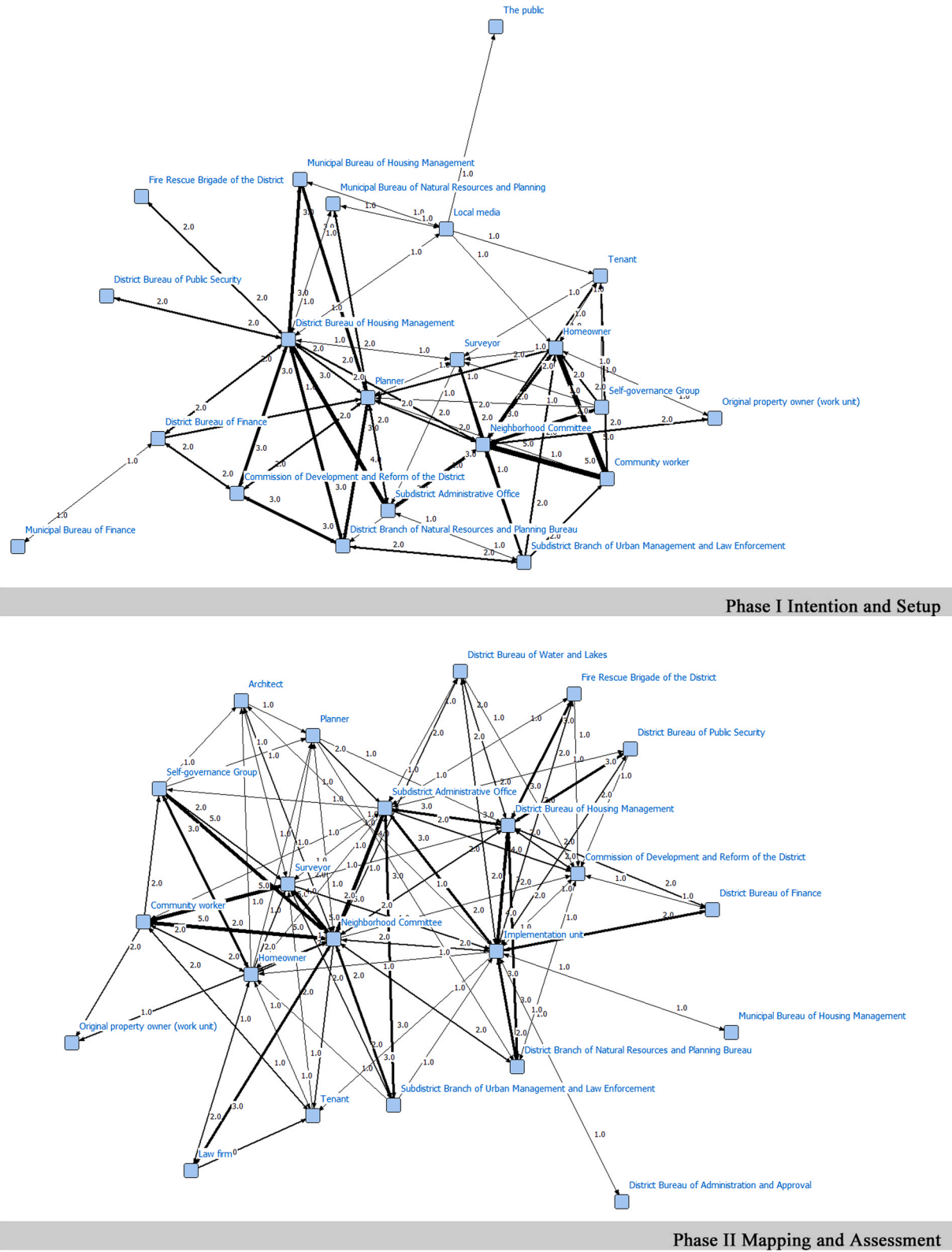
Fig. 4.2. Evolution of the information network for Jiaoweiyuan rehabilitation over the project lifecycle. Note: The arrow indicates the direction of information sharing, from provider to receiver. The score represents the frequency of information sharing and is close to the information provider: 1 - only once, 2 - two to three times, 3 - multiple times, but not weekly, 4 - once a week, and 5 - several times a week.
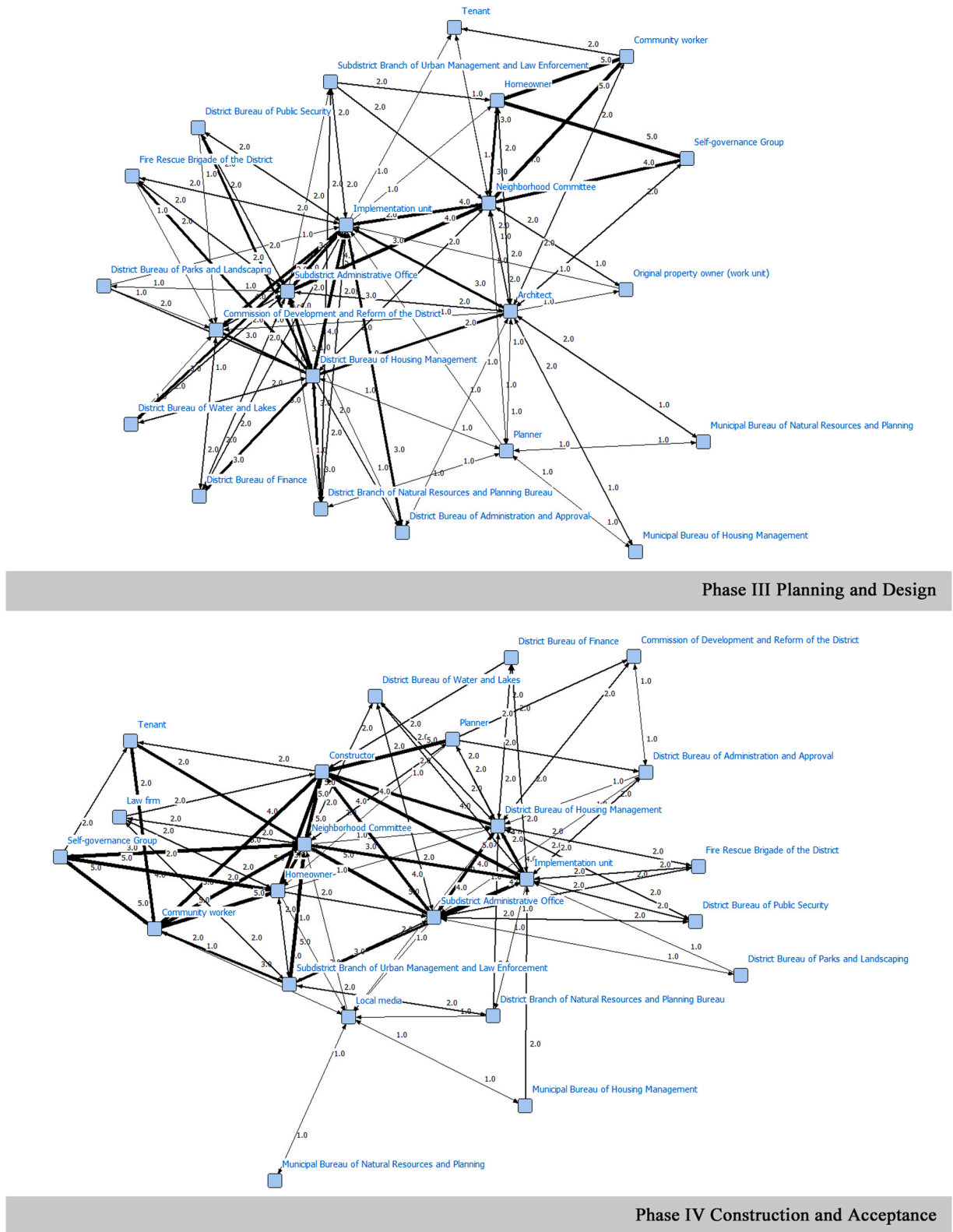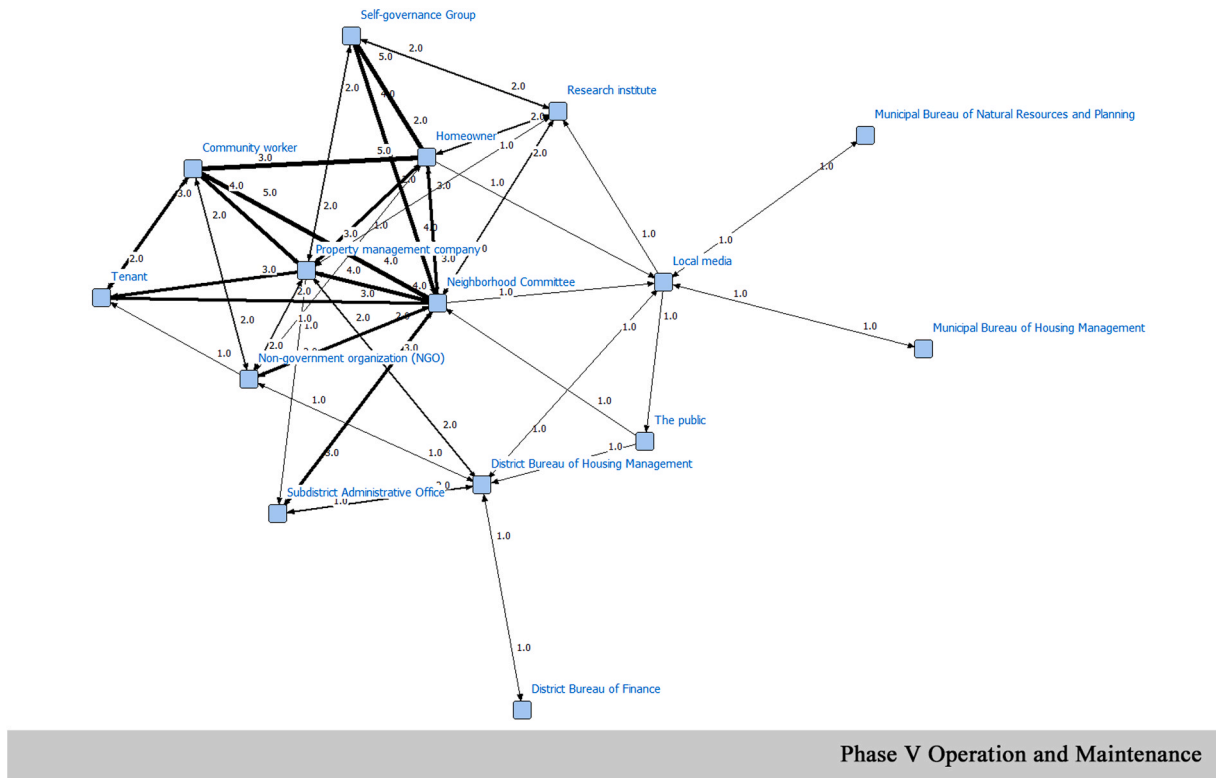
Phase III Planning and Design

Phase IV Construction and Acceptance

Fig. 4.2. (*continued*).

Fig. 4.2. (*continued*).

throughout the process. Notably, its influence was minimal during Phase I and Phase V, where it neither acted as a distributor of information nor received significant input from other stakeholders, positioning it at the network's periphery. Nevertheless, its influence surged during the middle three phases, placing it at the network's core. Despite this, its ability to distribute and receive information remained limited, slightly better than homeowner and architect.

Neighborhood committee occupied a central position within the network throughout the project lifecycle. It ranked first or second in the centrality index, acting as the primary information sender and receiver. Moreover, the committee demonstrated high control and maintained significant independence within the network. Its influence remained consistently high, reaching its peak during Phase II and Phase IV, and slightly weakening during Phase III. As noted by numerous respondents, neighborhood committee served as the most crucial source of information and their preferred channel for obtaining information about other stakeholders:

"…they really get the overall situation and have the big picture in mind. They also know which residents tend to stir up trouble or conflict. Focusing on these residents could have much more effective results." (implementation unit respondent, in-person survey, 10th September 2022)

"We always show the design plans to the committee first since they know which parts might raise residents' concerns… Once they give the nod, we then share it with the residents. I also noticed that residents preferred communicating with them rather than us." (architecture firm respondent, in-person survey, 18th June 2022)

Implementation unit and Architect exhibit a similar pattern, being involved during the middle three phases, with their influence increasing

and subsequently declining. During Phase III, Implementation unit replaced Neighborhood committee and Housing bureau, assuming the role of the primary disseminator and recipient of information, while Architect exerted the greatest control. However, there is a significant disparity in the extent of influence between them. In Phases II and IV, Implementation unit significantly outperformed Architect in terms of its ability to disseminate and receive information, exercise control over information flow, and independence. Additionally, Fig. 4.2 illustrates that implementer is positioned at the core of the information network, while Architect often occupies the periphery.

Homeowners were positioned in the central part of the information network, except for Phase IV. However, their influence on information sharing remains consistently low, only surpassing that of local media. Lower degree centrality scores indicate that residents were neither the primary recipients nor the senders of information. Their control over information was minimal, and their exchange heavily depended on other stakeholders. However, their influence was notably improved during Phase V. Their capacity to transmit and receive information ranked second, transitioning from the network's periphery to its core. Participants in the homeowner focus group suggested an increase in residents' discourse power as the process advanced:

"…we liked the original gate, but the government wanted something more culturally reflective, leading to its redesign and rebuild…while more recently, upon finding an empty space in the neighborhood, we hired an architect. She and the committee suggested a children's playground, but we rejected that idea. We preferred a neighborhood canteen instead."

Local media participated in Phases I, IV, and V, with consistently minimal influence on information sharing. In Phase I, it occupied a relatively central position (Fig. 4.2), facilitating effective communication with residents. However, its low centrality suggests a lack of trust
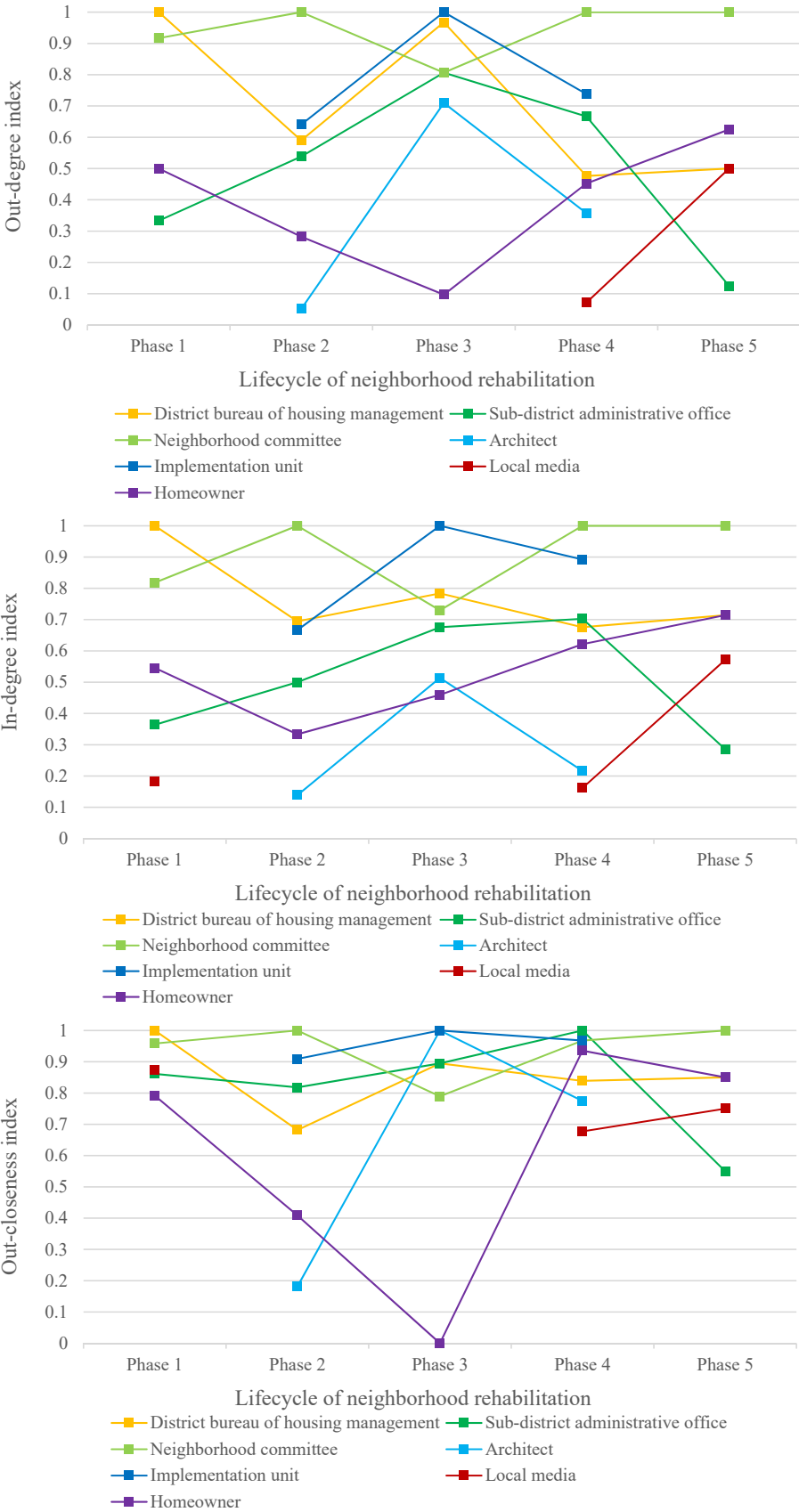
Fig. 4.3. Evolution of centralities of seven critical stakeholders over the project lifecycle.
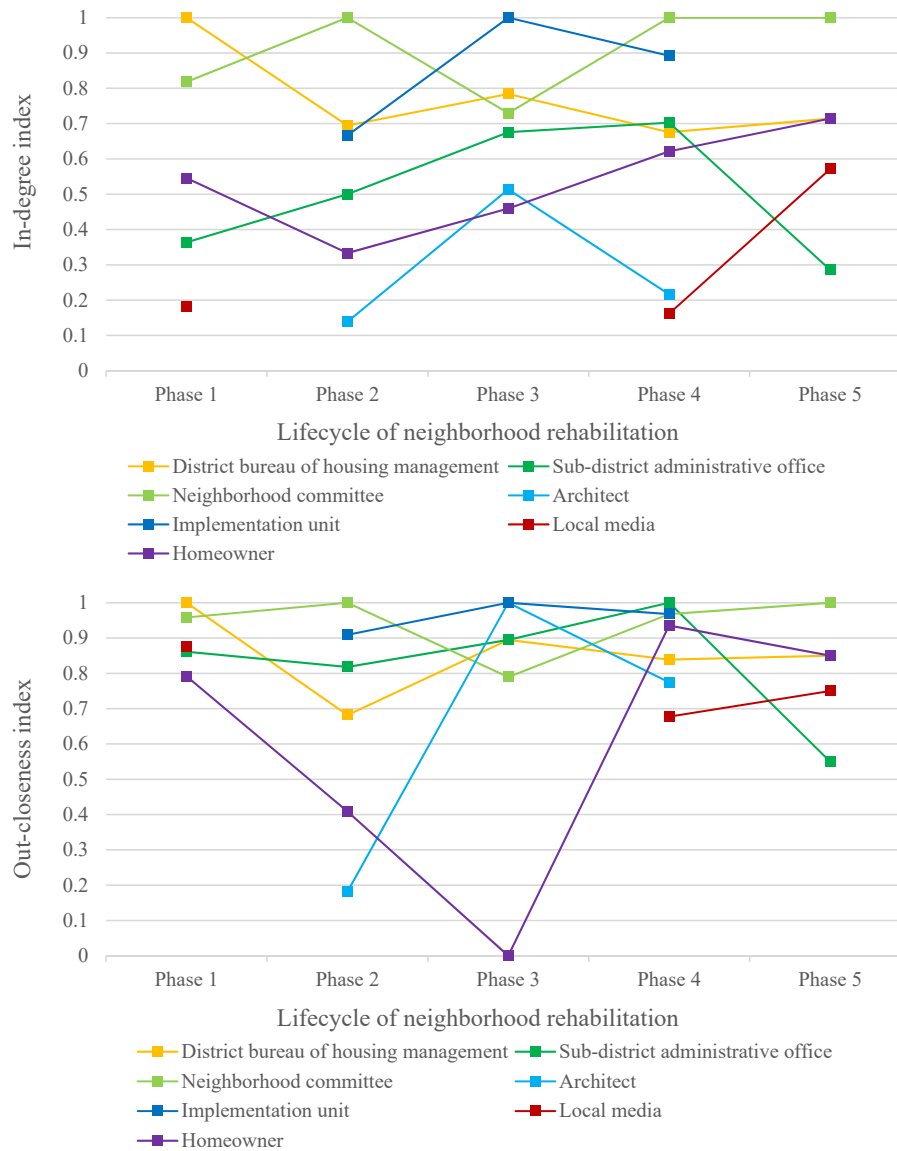
Fig. 4.3. (*continued*).

from other stakeholders in providing information. The media's influence remained low in Phase IV, while surged in Phase V, where it became the primary information controller. Despite this, its capacity to send and receive information was limited, relying heavily on other stakeholders. One respondent from local media (a local documentary director) offered insights into this information dependence:

"...*we tried reaching out to residents ourselves before, but they tend to be wary of us... That is why we contacted the housing bureau first this time. With the help of the bureau and the committee, the contact and communication were very smooth.*"

4.2.3. Influence of interrelationship between stakeholders

Fig. 4.4 depicts the integral mutual relationships (Sign*U*) among the seven stakeholders in the information network, showcasing the integral impact of these dyads on information sharing and the evolution of these

relationships and impacts across different phases. *MI* ranges from 1.08 to 1.77, indicating a mutualistic network. *SI* ranges from 2.99 to 5.85, suggesting a synergistic information system.

In Phase I, three types of relationships exist among stakeholders: mutualism, exploitation, and competition, accounting for 10 %, 60 %, and 30 %, respectively. Competitive relationships were observed between Homeowner-Subdistrict office, Media-Housing bureau, and Media-Neighborhood committee. Housing bureau emerged as the primary beneficiary of information sharing. Media and Homeowner were the primary contributors to information exploitation by Housing bureau, Subdistrict office, and Neighborhood committee.

Moving into Phase II, a new dyadic relationship emerged: neutral. Housing bureau maintained a neutral relationship with Subdistrict office, Neighborhood committee, Architect, Implementation unit and Homeowner. Two pairs of relationships changed: the competitive relationship between Homeowner-Subdistrict office shifted to exploitation,
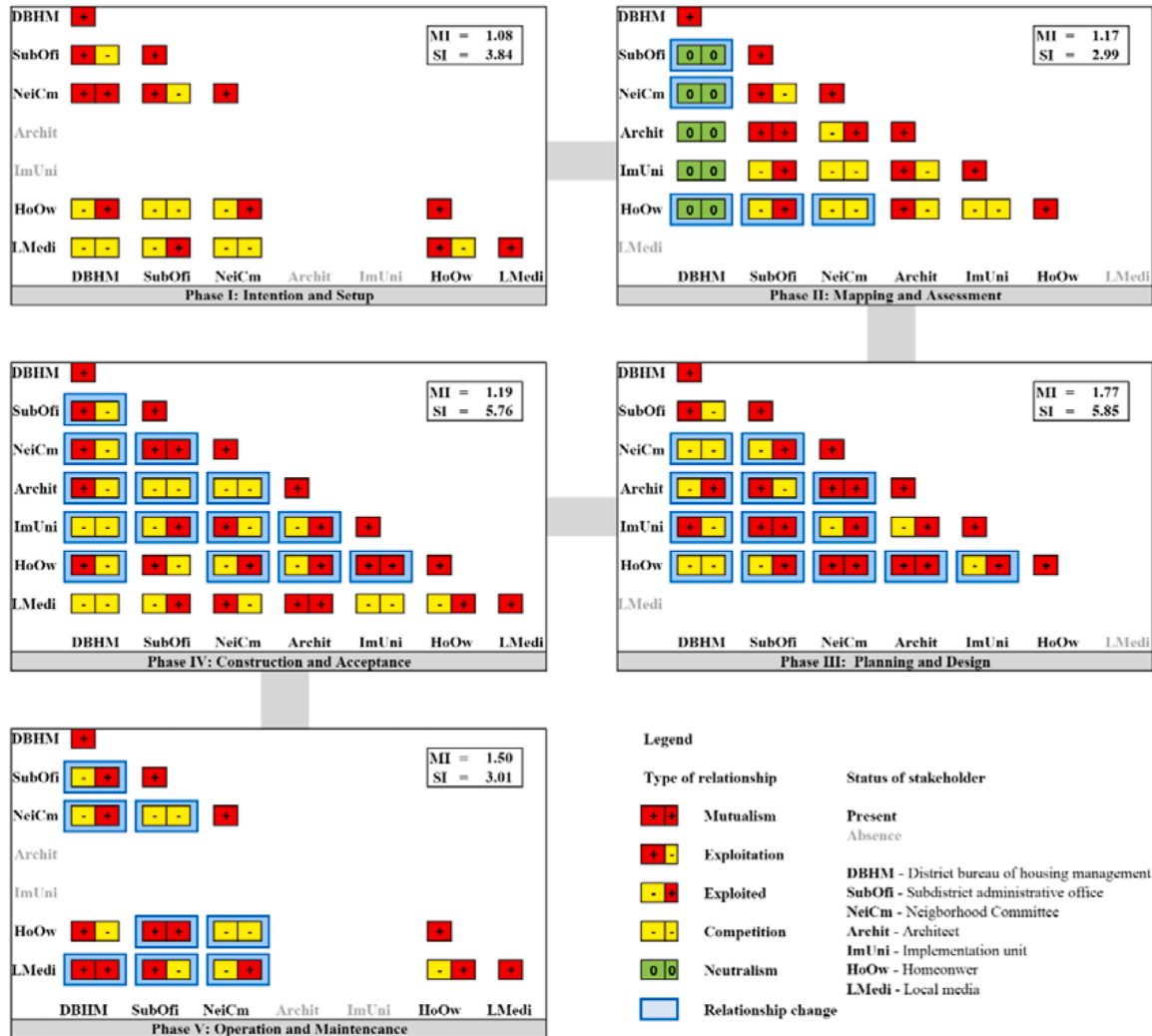
Fig. 4.4. Integral mutual relationship (Sign*U*) for information sharing in Jiaoweiyuan rehabilitation. Note: In each Sign*U*, the left symbol represent stakeholder in row, and the right symbol reflects the status of the stakeholder in column. The blue blocks indicate that the interrelationship between these two stakeholders differs from the previous phase. *MI* is the mutualism index and *SI* is the synergism index of the information network.

and the exploited relationship between Homeowner-Neighborhood committee shifted to competition. Competitive relationships also emerged between Implementation unit-Neighborhood committee and Homeowner-Implementation unit. Furthermore, Homeowner became the most prominent information provider, exploited by Subdistrict office, Neighborhood committee, and Implementation unit. Conversely, Subdistrict office emerged as the primary information beneficiary, exploiting Architect, Implementation unit, and Homeowner.

In Phase III, significant shifts occur in all relationships, except for two exceptions in Subdistrict office-Housing bureau and Implementation unit-Architect. Competitive relationships arise in Neighborhood committee-Housing bureau and Homeowner-Housing bureau. The proportion of mutualism relationships increases to 26.7 % (4/15), including Architect-Neighborhood committee, Implementation unit-Subdistrict office, Homeowner-Neighborhood committee, and Homeowner-Archit. Housing bureau emerged as the primary information contributor, exploited by four stakeholders (Subdistrict office, Neighborhood committee, Implementation unit, Homeowner), with Subdistrict office and Neighborhood committee benefiting the most.

By Phase IV, all relationships change, with mutualism, exploitation, and competition accounting for 14.3 %, 61.9 %, and 23.8 %, respectively. Housing bureau continued as the primary contributor, exploited by the other six stakeholders, notably benefiting Subdistrict office (exploiting Neighborhood committee, Implementation unit, Media) and Architect (exploiting Implementation unit, Homeowner, Media). Architect's relationships face significant challenges, with two-thirds being competitive.

In Phase V, competitive relationships emerge in Neighborhood committee-Subdistrict office and Homeowner-Neighborhood committee, while Homeowner-Subdistrict office and Media-Housing bureau exhibit mutualism. Roles were reversed for Housing bureau and Homeowner, with Housing bureau becoming the primary information beneficiary, exploiting Subdistrict office, Neighborhood committee, and Media. In contrast, Subdistrict office transited to the main contributor, exploited by Neighborhood committee and Subdistrict office.

5. Discussion

5.1. Stakeholder information sharing and evolution in the view of SNA and ENA

5.1.1. Neighborhood committee – primary information broker, yet heavily exploited

The case of Jiaoweiyuan rehabilitation highlights the neighborhood committee as a pivotal and influential stakeholder in information sharing, evidenced by its possession of the most comprehensive and detailed information (Fig. 4.1). Throughout the project's lifecycle, the committee was integral to the information network, serving as both the primary distributor and recipient of information (Fig. 4.2, Fig. 4.3). Except for Phase III Planning and Design, the committee wielded substantial control with minimal interference from other stakeholders. This central function is consistent with findings by Z. Liu et al. (2023) in eight Chinese cities, where neighborhood committee not only facilitated horizontal connections among residents, designers, and execution units, but also established hierarchical relationships with government entities. Beyond these "liaison" and "representative" roles (Parise, 2007), this study reveals its additional role as an "advisor," aimed at facilitating internal communication and thereby fostering consensus and trust among the residents.

Despite this, ENA results indicate that the committee has been exploited by other stakeholders throughout the project lifecycle, contributing significantly more to information sharing than it receives

(Fig. 4.4). Additionally, its role as an information hub was not spontaneously occurring (Z. Liu et al., 2023). In the short term, this exploitation allows governmental bodies and designers to access and understand the neighborhood swiftly, facilitating adequate supervision and informed designs. However, the excessive exploitation, compounded by insufficient feedback, hindered the committee from accumulating information and trust from the residents. A discernible impatience and dwindling confidence in communicating with residents have also emerged among some stakeholders.

Notably, this over-reliance on information sharing jeopardizes the long-term viability of rehabilitation initiatives. Complaints like "*Dealing with residents' feedback often keeps us busy until midnight,*" "*If we don't promptly respond to residents, they complain to the government. Besides communicating with residents, we spend considerable time briefing the government,*" and "*The workload is overwhelming, leading us to opt out of future rehabilitation rounds,*" underscore the committee's predicament. Additionally, the committee's exclusive and indispensable role within the information network raises the network's fragility. The absence of redundancy in the network implies that if the committee were to burn out, lose contact with other groups, or be impacted by sudden events, the project's information network faces a significant risk of collapse (Tononi et al., 1999). Therefore, while affirming the critical role of the committee in facilitating cross-boundary communication (Z. Liu et al., 2023), an increasing focus on building prestige and trust among other stakeholders is advocated. Cultivating backup stakeholders and interactions can prevent the overexploitation of community workers and ensure the resilience of the information network.

5.1.2. Homeowners – a rise and monopolization of the discourse power

As the project progressed, residents' discourse power increased noticeably, transitioning from passive compliance with predefined decisions to possessing ultimate decision-making authority. This transformation is attributed to the residents' increasingly pivotal role within the information network (Fig. 4.2), as well as their innovative communication strategies. In the case of Wuhan, residents utilized multiple avenues to have their voices heard by higher levels of government. As noted by participants in the homeowner focus groups, they called the mayor's hotline, reached out to provincial Chinese People's Political Consultative Conference (CPPCC) and National People's Congress (NPC) deputies, commented on the government's social media accounts, and resorted to legal action by filing lawsuits, to urge grassroots governments to respond to their appeals. The accumulation of residents' discourse power is further evidenced by their transition from contributors to beneficiaries in the information network (Fig. 4.4). Their information interdependency with other stakeholders evolved from exploitation and competition during the initial three phases to exploitation and mutualism in Phases IV Construction and Acceptance and V Operation and Maintenance.

Despite this positive shift in discourse power, the study underscores a persistent challenge in urban planning research—the underestimation of residents' contributions by decision-makers and the opaqueness of the decision-making process (Enserink and Monnikhof, 2003; Liu, Hu et al., 2018). The SNA results indicate that residents were not the primary sources of information, nor did information flow to them freely. More critically, residents held minimal control and relied heavily on other stakeholders to voice their opinions and acquire information. This informational vulnerability peaked in Phase III Planning and Design, where the residents' input was most needed.

Another notable trend is the stratification of residents' information roles. During Phase I Intention and Setup, neighborhood committee consciously recruited neighborhood leaders and cultivated them into activists. These activists, enriched with rehabilitation knowledge and

communication skills, became the information "gatekeepers" (Parise, 2007). In subsequent phases, external insights were filtered through these activists and relayed to the broader population. Jiaoweiyuan case reports substantial success with this layered messaging, as the head of the neighborhood committee exemplified:

"*…upon receiving a task, we convened a meeting with the activists to align our understanding and, more critically, ensured consistency in our messages… it took months to gather questionnaire responses in other neighborhoods, we managed it within a week…when complaints arise, we delegate mediation to activists familiar to the concerned resident, as direct intervention from us might be perceived as administrative overreach.*"

Nevertheless, not all gatekeepers were committed to facilitating information sharing. Sometimes, they marginalized vulnerable groups and suppressed voices with conflicting interests, exacerbating inequalities in the participatory process. This phenomenon mirrors observations by Boyle and Michell (2020) during a collaborative regeneration project in South Africa. In Jiaoweiyuan rehabilitation, homeowner representatives refused to inform UBW violators about the time and location of the demolition seminar, excluding them from a crucial negotiation with the working group. During the meeting, these homeowners fabricated the views of the violators, resulting in the latter's displacement.

5.1.3. Local media – competent participation promoter, but nowhere near whistleblower

Media is often recognized as influential in promoting public participation (Yang and Callahan, 2007; Yu et al., 2021). This influence stems from its ability to highlight environmental issues and potential benefits of the renovation technologies, thereby sparking residents' desire to initiate environmental improvements (Jia et al., 2021). Widespread sensitization on the importance of and opportunities for participation enables residents' timely involvement (Yang and Callahan, 2007). The Jiaoweiyuan case contributes by exemplifying how media coverage can motivate the lay public to pursue rehabilitation efforts. One participant in the public focus group noted, "*I read in the newspaper that Jiaoweiyuan's appearance has improved greatly. So, I contacted my neighborhood committee and asked if our neighborhood could also be renovated.*" For Jiaoweiyuan residents, the publicity boosted their residential satisfaction and eagerness for ongoing engagement. The homeowner focus group participants remarked, "*…seeing the photos of the before and after rehabilitation, I felt fortunate. I thought I had to do something to maintain this hard-won good life.*"

Despite the media's capacity to engage various resident groups, there is significant distrust towards it among stakeholders. SNA results reveal stakeholders were hesitant to voluntarily share information with the media, even though it held considerable control over information dissemination (Fig. 4.3). Additionally, ENA results indicate that the local media adopted an exploitative role throughout the project's lifecycle, casting doubts on its ability to function as an independent agent. This finding challenges the conventional expectation, as noted by Yu et al. (2021), that the media should act as a whistleblower in construction projects.

In the Jiaoweiyuan case, local media was constrained from challenging government directives or championing increased decision-making power for residents. Its dependency on the government and the neighborhood committee for information starkly contrasts the independence reported by Zheng et al. (2024) in an urban village renovation project in Tianjin. Instead, it aligns more closely with Wu (2023)'s observations of a public infrastructure project in Shanghai, where the media was limited to disseminating the positive aspects of the projects. Concerningly, media coverage was predominantly published on government platforms, suggesting that the intended audience was the governmental apparatus rather than the residents or the broader society.

5.2. Policy recommendations

Policy recommendations are made to rectify unhealthy interrelationships and curb undesirable stakeholder behaviors. Given the case of Jiaoweiyuan rehabilitation, these recommendations address the issues of information exploitation by neighborhood committee, manipulation by homeowners, and the loss of media autonomy, respectively.

To counteract information exploitation by neighborhood committee, this study suggests integrating redundancy nodes and relationships within the information network. Traditionally supported by academia and government, community planner schemes favor design experts (Hui et al., 2021; Li et al., 2020; SC, 2020a; Shen et al., 2021). However, this research advocates a shift toward appointing community opinion leaders as planners, emphasizing that their trust and relational capital are more vital for effective information exchange than merely technical expertise. Despite the benefits, reliance on manual processes exposes planners to exploitation. As a novel solution, this study recommends integrating sensors and computer algorithms to automate information capture and distribution, enhancing efficiency and reducing manual dependency. Crucially, while the development of digital communication platforms is promising and advocated by many scholars (Nita et al., 2022; Zhang et al., 2021), this study shifts the focus towards enhancing user interaction rather than merely aggregating data within these platforms. The implementation of AI-powered chatbots is suggested to improve resident engagement and the accuracy of information dissemination, simplifying the neighborhood committee's role to verifying and clarifying data.

By using objective data from devices and directly transmitting subjective data from the source, this platform can also mitigate information manipulation by specific residents. Nevertheless, this shift in communication requires significant investment in time, resources, and training to ensure users are effectively engaged and the technology achieves its intended purpose. Consequently, scholars often prefer immediate solutions, such as diversifying information channels (He et al., 2015), establishing platforms for conflict resolution (Nita et al., 2022), introducing monitoring mechanisms (Zhou et al., 2022), and enacting laws (Zhang et al., 2021). Nevertheless, the Jiaoweiyuan case highlights additional challenges such as the uneven selection of delegates and the "train the trainer" method used by the committee for information dissemination. To address uneven representation, this study suggests a resident jury scheme. Although well-recognized internationally, it remains underutilized in Chinese academic and practical contexts. In this scheme, project beneficiaries and detractors present their cases, leaving decision-making to randomly selected citizen jurors with no direct stakes in the project. Regarding the "train-the-trainer" approach, despite its effectiveness in speeding up information spread and broadening public participation, it introduces exclusivity and unfairness, necessitating careful refinement. Contrary to typical practices of targeting children or retirees for training (Dickens, 2013; Li et al., 2024; Luo et al., 2020), this paper recommends focusing on adolescents[2] due to their enthusiasm for new ideas and more mature judgment, with a lower likelihood of being influenced by personal interests, therefore can minimize bias in information dissemination.

The Jiaoweiyuan case highlights distrust in local media, exacerbated by their limited autonomy in reporting, controlled by regional powers rather than central authorities (Jingrong, 2010). This is evident in strategies implemented during the Enning Road renovation in Guangzhou, where provincial-level media were brought into spotlight misconduct in district-level initiatives (Yu et al., 2021). This tactic aligns with Chinese Communist Party (CCP) directives that encourage the media to monitor public opinion and expose flaws in lower-level administrations (Jingrong, 2010), an approach this study advocates to mitigate local

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[2] The World Health Organization (WHO) defines an adolescent as a human between ages 10 and 19.

media autonomy issues. However, a broader solution involves reforming the legal framework for information, as the current *Cybersecurity Law* focuses narrowly on security and monitoring without adequately supporting freedom of discourse. Recommended reforms include enacting legislation that guarantees media report accuracy and, more importantly, protects journalists' and citizens' freedom to express opinions without fear of censorship or retribution. Drawing on international examples like the U.K.'s *Freedom of Information Act*, the U.S.'s *First Amendment, Article 10 of the European Convention on Human Rights*, and Hong Kong's *Personal Data (Privacy) Ordinance* could guide these reforms. Such reforms would enhance media credibility and independence, fostering a more transparent and informed public discourse.

5.3. Strength and limitations

The study presents strengths and limitations, setting directions for future research. Firstly, recognizing SNA's limitation in capturing nuanced relationships within networks, this research integrates ENA to explore stakeholders' influence on information networks, networks' consequential impacts, and their effects on resident participation in neighborhood rehabilitation. It indicates that ENA effectively complements SNA by revealing detrimental relationships, such as exploitation and competition, which often remain obscured within SNA research. Furthermore, this study addresses the growing scholarly demand for exploring the dynamic nature of construction projects through longitudinal research, thereby securing a unique position within existing literature. However, the study's retrospective single-case study design limits its scope to investigating transpired phenomena and existing challenges, thus lacking foresight and generalizability—common constraints in SNA studies. Despite these limitations, notable advancements have been made by incorporating additional network motifs, as demonstrated by the work of scholar Andreea Nita. For instance, employing data from European conservation projects, Nita et al. (2016) combine SNA and the Exponential Random Graph Model (ERGM) to understand intra- and inter-country collaboration and, more importantly, predict trends in re-cooperation. More recently, leveraging data from global EIA researchers, Nita et al. (2022) apply a two-mode network approach to delineate the optimal stakeholder composition and their ideal level of involvement for each phase of the EIA lifecycle. These innovative approaches offer valuable methodologies for future research to conduct more predictive or scenario-based studies.

Secondly, this study examines the sharing behavior and relationships of different stakeholders and how they evolve during the various phases of rehabilitation. However, in line with Weimann (1982), the content of information and focus of sharing vary in phases, which in turn influence the partner, direction, and frequency of sharing. Given this dynamic, future research could focus on one or more of the identified nine types of information to conduct detailed studies to enhance the efficiency of specific information dissemination.

Finally, this study assumes that sufficient information sharing facilitates public participation. Nonetheless, an increasing number of scholars (Jia et al., 2021; Li et al., 2024) and schools of thought (e.g., behavioral economics Camerer et al. 2004 and transaction costs Ketokivi and Mahoney 2016) argue that public is not guaranteed to participate by having more information, especially given their limited rationality and uneven information-processing capabilities. Hence, future research could explore the tipping point of information sharing and determine the appropriate quantity and quality of information that encourages public participation without overwhelming or underwhelming the target audience.

6. Conclusions

Sustainable urban renewal hinges on active public participation, necessitating effective information sharing. This study makes an important step in this regard by longitudinally exploring stakeholder information sharing throughout the project lifecycle of neighborhood rehabilitation and its impacts on resident participation. It shows that SNA and ENA are complementary and competent in identifying critical stakeholders while uncovering undesirable behaviors such as manipulation and monopolization, and highlighting unhealthy relationships like exploitation and competition. Centered on a typical and inspiring neighborhood rehabilitation project in Wuhan, China, the study identifies 31 stakeholders, illustrating the complexity and dynamism of the information network within rehabilitation. Stakeholders influence this network, which in turn subtly informs their objectives and dissemination strategies. Neighborhood committee and local media emerged as most crucial in sharing information as well as promoting resident participation. Through innovative communication models, Neighborhood committee enabled rapid and extensive information flow, enhancing residents' sense of empowerment and boosting their enthusiasm for engagement. Concurrently, local media coverage increased public awareness of the rehabilitation initiatives, encouraging actions to improve living conditions and heightening the residential satisfaction of residents in rehabilitated neighborhoods, thereby promoting their ongoing involvement.

However, the findings indicate that stakeholders' over-reliance on and exploitation of neighborhood committee for information sharing eroded the committee's willingness, capacity and trust to disseminate information during the later project phases. This avoidance and shifting of communication responsibilities led to a fragile information network and further marginalized local media, undermined by dwindling trust and autonomy. Homeowners amplified their discourse power as the project progressed, shifting from passive recipients to active decision-makers. Yet, well-informed homeowners monopolized information sharing, deliberately excluding others with conflicting interests, intensifying the inequity and opacity of the participation process.

In response, it is crucial to introduce redundancies and broaden relationships within the currently over-concentrated information network. Instituting community planners or engaging NGOs can mitigate information exploitation by neighborhood committee and enhance network resilience. Breaking information manipulation by certain residents could involve diversifying information recipients, such as training youth in information dissemination. However, fundamentally addressing these challenges requires a radical shift in information-sharing model. Deploying data collection devices, utilizing computer algorithms and machine learning for processing, and employing AI-powered chatbots for distribution can drastically reduce reliance on human intervention and biases. Additionally, urgent legal reforms are necessary to protect the freedom of expression for media and citizens from interference and threats by interest groups. As envisioned by this study, such enhanced information-sharing behaviors and relationships will promote more transparent, equitable, inclusive, and sustainable public participation in urban (re)development.

Intellectual property

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

Research ethics

We confirm that any aspect of the work covered in this manuscript that has involved human participants has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

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CRediT authorship contribution statement

Yu Li: Writing – original draft, Visualization, Software, Methodology, Formal analysis, Conceptualization. **Penglin Zhu:** Writing – review & editing, Resources, Investigation, Data curation, Formal analysis. **Erwin Mlecnik:** Writing – review & editing. **Queena Qian:** Supervision. **Henk Visscher:** Writing – review & editing, Supervision.

Declaration of Competing Interest

No conflict of interest exists. We confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data Availability

Data will be made available on request.

Appendix A. Questions used in in-person survey and focus group discussion

Section 1: **Level of information possession**						
Question		Response				
1	For the following types of information, to what extent are you informed? (1 - No knowledge, 2 - Poor knowledge, 3 - Average knowledge, 4 - Good knowledge, 5 - High knowledge)	1	2	3	4	5
	a. Policy and regulations	☐	☐	☐	☐	☐
	b. Administrative arrangement	☐	☐	☐	☐	☐
	c. Project information	☐	☐	☐	☐	☐
	d. Indigenous knowledge and experience	☐	☐	☐	☐	☐
	e. Objectives and concerns	☐	☐	☐	☐	☐
	f. Design information	☐	☐	☐	☐	☐
	g. Construction information	☐	☐	☐	☐	☐
	h. Management information	☐	☐	☐	☐	☐
	i. Participation information	☐	☐	☐	☐	☐

Section 2: Network questions

In *Phase I* Intention and Setup:

2 Please select from the following list of stakeholders with whom you exchanged project information:
3 In what Direction? (R – receive, P – provide, RP – both occurred)
4 How frequently was information shared? (1 - Shared only once, 2 - Shared two to three times, 3 - Shared multiple times, but not weekly, 4 - Shared once a week, 5 - Shared several times a week)

Stakeholder list (skip the row if no information was shared with this stakeholder)	Direction (Q3)			Frequency (Q4)				
	R	P	RP	1	2	3	4	5
(1) Bureau of Housing Management	☐	☐	☐	☐	☐	☐	☐	☐
(2) Bureau of Finance	☐	☐	☐	☐	☐	☐	☐	☐
(3) Natural Resources and Planning Bureau	☐	☐	☐	☐	☐	☐	☐	☐
…	☐	☐	☐	☐	☐	☐	☐	☐
(29) Homeowner	☐	☐	☐	☐	☐	☐	☐	☐
(30) Tenant	☐	☐	☐	☐	☐	☐	☐	☐
(31) The public	☐	☐	☐	☐	☐	☐	☐	☐

In *Phase II* Mapping and Assessment:

…

In *Phase V* Operation and Maintenance:

2 Please select from the following list of stakeholders with whom you exchanged project information:
3 In what Direction? (R – receive, P – provide, RP – both occurred)
4 How frequently was information shared? (1 - Shared only once, 2 - Shared two to three times, 3 - Shared multiple times, but not weekly, 4 - Shared once a week, 5 - Shared several times a week)

Stakeholder list (skip the row if no information was shared with this stakeholder)	Direction (Q3)			Frequency (Q4)				
	R	P	RP	1	2	3	4	5
(1) Bureau of Housing Management	☐	☐	☐	☐	☐	☐	☐	☐
(2) Bureau of Finance	☐	☐	☐	☐	☐	☐	☐	☐
(3) Natural Resources and Planning Bureau	☐	☐	☐	☐	☐	☐	☐	☐
…	☐	☐	☐	☐	☐	☐	☐	☐
(29) Homeowner	☐	☐	☐	☐	☐	☐	☐	☐
(30) Tenant	☐	☐	☐	☐	☐	☐	☐	☐
(31) The public	☐	☐	☐	☐	☐	☐	☐	☐

Appendix B. Centrality index of stakeholders in Jiaoweiyuan rehabilitation

	Out-degree					In-degree					Out-closeness					In-closeness					Betweenness				
	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V	I	II	III	IV	V
Municipal Bureau of Housing Management	0.20	0.00	0.00	0.05	-	0.08	0.00	0.05	0.00	-	0.47	0.00	0.05	0.48	-	0.45	0.00	0.09	0.00	-	0.00	0.00	0.00	0.01	-
Municipal Bureau of Finance	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-	0.00	-	-	-	-
Municipal Bureau Natural Resources and Planning	-	-	0.00	0.00	-	0.08	-	0.05	0.00	-	0.43	-	0.05	0.00	-	0.58	-	0.09	0.00	-	0.00	-	0.00	0.00	-
District Bureau of Housing Management	1.00	0.59	0.97	0.48	0.50	1.00	0.69	0.78	0.68	0.71	1.00	0.68	0.89	0.84	0.85	1.00	0.86	0.87	1.00	1.00	1.00	0.25	0.45	0.84	0.70
District Bureau of Finance	0.24	0.10	0.23	0.12	0.00	0.17	0.14	0.19	0.08	0.00	0.57	0.09	0.21	0.55	0.08	0.55	0.14	0.26	0.41	0.00	0.23	0.00	0.00	0.00	0.00
District Branch of Natural Resources and Planning Bureau	0.28	0.18	0.16	0.10	-	0.38	0.22	0.19	0.05	-	0.60	0.45	0.32	0.58	-	0.77	0.52	0.35	0.37	-	0.06	0.02	0.02	0.02	-
District Bureau of Administration and Approval	-	0.00	0.10	0.10	-	-	0.00	0.16	0.14	-	-	0.00	0.42	0.55	-	-	0.00	0.52	0.37	-	-	0.00	0.00	0.06	-
Commission of Development and Reform of the District	0.36	0.10	0.26	0.05	-	0.38	0.28	0.38	0.11	-	0.60	0.14	0.21	0.23	-	0.71	0.71	0.74	0.33	-	0.04	0.04	0.02	0.01	-
District Bureau of Water and Lakes	-	0.18	0.19	0.17	-	-	0.14	0.14	0.19	-	-	0.50	0.21	0.71	-	-	0.48	0.22	0.63	-	-	0.00	0.00	0.01	-
District Bureau of Parks and Landscaping	-	-	0.10	0.02	-	-	-	0.00	0.00	-	-	-	0.21	0.45	-	-	-	0.00	0.11	-	-	-	0.00	0.00	-
Fire Rescue Brigade of the District	0.04	0.15	0.16	0.12	-	0.04	0.14	0.16	0.14	-	0.43	0.32	0.21	0.52	-	0.45	0.14	0.22	0.44	-	0.00	0.00	0.00	0.00	-
District Bureau of Public Security	0.04	0.15	0.16	0.12	-	0.04	0.14	0.16	0.14	-	0.43	0.32	0.21	0.52	-	0.45	0.14	0.22	0.44	-	0.00	0.00	0.00	0.00	-
Subdistrict Administrative Office	0.33	0.54	0.81	0.67	0.13	0.36	0.50	0.68	0.70	0.29	0.86	0.82	0.89	1.00	0.55	0.76	0.76	0.87	0.89	0.64	0.03	0.31	0.55	0.76	0.02
Subdistrict Branch of Urban Management and Law Enforcement	0.32	0.23	0.19	0.43	-	0.21	0.14	0.05	0.43	-	0.57	0.50	0.32	0.77	-	0.55	0.29	0.17	0.70		0.06	0.00	0.00	0.28	-
Neighborhood Committee	0.92	1.00	0.81	1.00	1.00	0.82	1.00	0.73	1.00	1.00	0.96	1.00	0.79	0.97	1.00	0.91	1.00	0.83	0.93	1.00	0.53	1.00	0.51	1.00	0.60
Community worker	0.48	0.36	0.39	0.62	0.70	0.33	0.36	0.14	0.51	0.57	0.57	0.32	0.11	0.68	0.75	0.48	0.38	0.13	0.33	0.64	0.01	0.04	0.00	0.11	0.34
Self-governance Group	0.24	0.28	0.29	0.33	0.43	0.08	0.25	0.14	0.30	0.33	0.60	0.27	0.05	0.48	0.58	0.39	0.33	0.13	0.22	0.45	0.00	0.01	0.00	0.00	0.00
Planner	0.52	0.10	0.16	-	-	0.71	0.11	0.14	-	-	0.83	0.36	0.58	-	-	0.97	0.29	0.61	-	-	0.30	0.05	0.18	-	-
Architect	-	0.05	0.71	0.36	-	-	0.14	0.51	0.22	-	-	0.18	1.00	0.77	-	-	0.57	0.87	0.52	-	-	0.02	1.00	0.08	-
Surveyor	0.20	0.38	-	-	-	0.25	0.42	-	-	-	0.77	0.64	-	-	-	0.81	0.52	-	-	-	0.08	0.23	-	-	-
Implementation unit	-	0.64	1.00	0.74	-	-	0.67	1.00	0.89	-	-	0.91	1.00	0.97	-	-	0.95	1.00	0.96	-	-	0.98	0.79	0.93	-
Constructor	-	-	-	0.57	-	-	-	-	0.92	-	-	-	-	0.77	-	-	-	-	0.81	-	-	-	-	0.27	-
Original property owner (work unit)	0.08	0.00	0.00	-	-	0.08	0.08	0.05	-	-	0.43	0.09	0.21	-	-	0.42	0.14	0.13	-	-	0.00	0.00	0.00	-	-
Property management company	-	-	-	-	0.70	-	-	-	-	0.71	-	-	-	-	1.00	-	-	-	-	1.00	-	-	-	-	0.64
Law firm	-	0.15	-	0.17	-	-	0.06	-	0.14	-	-	0.18	-	0.52	-	-	0.14	-	0.26	-	-	0.00	-	0.00	-
Non-government organization (NGO)	-	-	-	-	0.39	-	-	-	-	0.29	-	-	-	-	0.92	-	-	-	-	0.82	-	-	-	-	0.34
Local media	0.50	-	-	0.07	0.50	0.18	-	-	0.16	0.57	0.85	-	-	0.68	0.75	0.52	-	-	0.78	0.93	0.17	-	-	0.70	0.02
Research institute	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.38	0.57	0.60	0.86	0.18
Homeowner	0.50	0.28	0.10	0.45	0.63	0.55	0.33	0.46	0.62	0.71	0.79	0.41	0.00	0.94	0.85	0.67	0.71	0.61	0.52	0.86	0.08	0.15	0.01	0.26	0.23
Tenant	0.08	0.05	0.00	0.07	0.04	0.21	0.19	0.11	0.30	0.43	0.47	0.05	0.00	0.42	0.00	0.48	0.57	0.52	0.37	0.64	0.00	0.02	0.00	0.01	0.01
The public	0.00	0.00	0.00	0.06	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.13	0.00	0.60	0.07	0.04

Note: "-" indicates that the stakeholder was not present at that phase.

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