

Article

Study on the Ecological Operation Model of Settlements Based on Social Network Analysis: Stakeholder Perspective

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Abstract: The appropriate ecological operation method is suggested in order to create a harmonious human settlement environment and achieve the sustainable development of residential areas. The key to determining whether the model can be successfully implemented is now the stakeholders. Scholars feel that stakeholders in the urban development process should sustain collaboration, and they suggest collaborative measures because they have successfully identified these parties. Nevertheless, there are distinctions between the specialized research of ecological operation stakeholders and the disregard for internal differences of related groups. In order to examine the relationship strength and network density, structural location, and role interaction, this article employs social network analysis to examine the cohesiveness, relevance, reciprocity, transitivity, hierarchy, and agency of the stakeholder relationship network in the ecological operation. Interest disagreements, solutions, and recommendations among participants encourage the effective application of the ecological operating model. The study demonstrates that there are no factions, and that weak links dominate the stakeholder relationship network in ecological operations, exhibiting a “core-periphery” relationship structure. High relevance, high reciprocity, and high transmissibility describe the relationship network. Although the network’s overall power is dispersed, each group’s power is centralized. Residents and social organizations in residential areas are in a poor position, since governments at all levels have strong control over them. In order to optimize relationships and collaborative governance, which is helpful for implementing the ecological operation mode and realizing harmony and oneness between man and nature, the study explored the relationship network structure and features of stakeholders in the ecological operation.

Keywords: settlement; ecological operation; social network analysis; cooperation; stakeholders



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1. Research Background

In the context of people’s increasingly high requirements for quality of life, the urban residential environment has become the focus of relaxation and enjoyment of life. At the same time, under the mainstream development form of sustainable development in the world at this stage, people are gradually looking for a richer, and more convenient and intelligent residential environment, based on the protection of the ecological environment. In 2020, the state released the “Fourteenth Five Year Plan” for the development of green buildings and green ecological urban areas, proposing to strengthen the operation and management of green ecological urban areas and improve the construction effect. In this context, it is very urgent and necessary to explore and study the construction and operation concept of urban ecology. In July 2018, in the face of the transformation of government functions and the reform of the housing system and mechanism, the Ministry of Housing and Urban-Rural Development officially approved the standard for planning and design of urban residential areas (GB50180-2018) [1], taking “residential neighborhood” as the basic space component unit of urban residential areas, to “promote the development of more open and convenient, appropriate scale, complete supporting facilities, and harmonious neighborhoods”. This will profoundly affect and change the social spatial pattern of urban

residential areas in China, and provide important support for cities to move towards an open and shared multi-level governance, and a harmonious and healthy developmental path. From the current operation of green residential areas, although the number of green residential projects in China has increased rapidly year by year, the number of projects that really meet the requirements in the operation stage only accounts for about 6~8% of the total [2], so many green residential areas have not achieved real “ecological” status. The ecological operation of residential areas is to build an ecological operation circle based on the green ecological construction of residential areas, pay attention to the harmony and unity of humans and nature, build a harmonious human settlement environment, extend the service life of ecological environmental resources, and achieve the sustainable development of ecological green residential areas. However, the ecological operation of residential areas is a complex system, and the management concept and mechanism are different from traditional urban residential area management. This requires the establishment of a complete set of operation and management mechanisms, which provide a platform for all stakeholders to participate in urban management, establish a stakeholder cooperation alliance, and jointly promote the development of residential areas, so as to ensure the good operation of residential areas. According to the existing research, scholars have conducted more evaluation and research into the economic benefits and environmental impact of residential areas [3], while social impact evaluation research reflecting the concept of “people-oriented” and coordinated sustainable development is relatively lacking, and there is less research into the ecological operation model itself. Therefore, from the perspective of stakeholder theory, based on social responsibility and adhering to the concept of sustainable development, this article studies the ecological operation mode in order to achieve sustainable development of residential areas.

In recent years, economists and relevant researchers have begun to explore coexistence and cooperation among cross-sectoral organizations [4,5]. Kujala et al. clarify the construct of stakeholder engagement to unfold the full potential of stakeholder engagement research [6]; Bahadorestani et al. develop a stakeholder engagement framework, enhancing the effectiveness of stakeholder engagement in projects [7]; Oppong et al. study the involvement of external stakeholders in decision-making and effective communication with external stakeholders [8]. Some scholars also apply stakeholder theory to sustainable urban construction and management [5]. Williams and Dair established a sustainability evaluation framework after their case study on the reuse of five brownfields in the United Kingdom. This framework includes the stakeholder analysis of brownfield development and the three-dimensional evaluation index system of society, economy and environment, which is widely used in the United Kingdom. They analyzed and studied the stakeholders involved in the brown land redevelopment, and emphasized the important link between the willingness and efforts of stakeholders and the achievement of sustainable goals [9]. Based on structured interviews with various stakeholders, Timothy uses the conceptual framework of sustainable development to investigate the sustainability of redevelopment projects [10]. Elsa and Lisa et al. proposed that brown land reuse is a key means of sustainable land use, and established a five-key-point (PoAs) matrix for successful reuse to identify the participation of key stakeholders [11].

Identification and classification in the study of stakeholders investigate the relationships between stakeholders and the game dilemma, choice behavior, and cooperative tactics of stakeholders [12]. In fact, academics have long understood that stakeholder relationships have an impact on business management, firm performance, and strategic goals [13–15] and that stakeholder cooperation is essential for the successful implementation of ecological operations. Yanhong Liang thinks that taking into account the many factors and stakeholder interests will advance their economic, environmental, and social objectives [16]. The involvement of various stakeholders influences sustainable development and generates advantages [17,18]. In conclusion, scholars have successfully identified the participants in the urban development process, established the structure, procedures, and goals of stakeholder classification, and supported the notion that participants should sustain col-

laboration and provide collaborative tactics. A solution to the issue of not being able to extend the binary inter-individual analysis to the overall analysis of complex systems and examine the structure and placement of participants in a systematic manner is social network analysis (SNA). SNA is a research method that has the potential for a continuum of fusion between quantitative and qualitative approaches [19]. Initially investigating social structures through the use of networks and graph theory, it has now been widely used in the fields of construction management [20], carbon emission transfer [21], low carbon supply chain [22], and project management [23–25]. Nguyen reveals that social network analysis strongly emerges as a valuable tool for analyzing the complexity of stakeholder interrelationships [26]. However, the findings of studies of stakeholders in ecological operation models from the perspective of SNA are uncommon. The purpose of this article is to further define the ecological operation's stakeholders, discuss them through classification, stratification, and clustering, and then analyze the structural traits of stakeholder organizations as a whole. Additionally, based on the social network analysis method, it quantifies and depicts the relationships between stakeholders, investigates the flaws of all levels of government and business, focuses on the involvement of residents and social organizations in residential areas, considers the needs and behaviors, relationships, and challenges faced by stakeholders in an ecological operation, and proposes solutions to conflicts and disagreements of interest.

2. Theoretical Basis and Research Methodology

2.1. Concepts Related to the Ecological Operation

Human civilization has been evolving toward an ecologically humane civilization all along. Ecological civilization emphasizes the nature of nature and bases its existence on the preservation and respect of nature. It emphasizes the peaceful coexistence of people and their relationships with society, nature, and other people. The study of the ideas of a simple linked ecological operation, follows.

Ecosystems are frequently discussed in combination with the biological notion of ecology. Ecosystems in nature are groups of living things that coexist well with their surroundings. Ecologicalization refers to the process in which biological, environmental, and ecological laws are applied to an ecosystem to promote both harmony throughout and sustainable development. Numerous industries are involved, including the ecological economy [27], tourism industry ecology [28], and construction activities [29], etc. The process of operation entails effective production and business activity planning, organization, and management, in order to achieve value growth. The effective operation involves a precise grasp of the environment's resources, procedures, technologies, monies, and people, in order to integrate these components into the operating system and to provide value [30].

Environmental protection, resource consumption, input–output ratio, sustainable development and other issues are all taken into account by the ecological operation, which is a form of operation designed in accordance with ecological regulations. The idea of ecological operation was first put forth as departing from the traditional mode of operation and emphasizing not only ecological harmony and the preservation of nature, but also the sustainable development of the economy, environment, culture, human health, and overall standard of living. Stakeholders and players in the operation process join forces and collaborate, to build an ecological operation mode with ecological characteristics in order to promote social peace, economic efficiency, an ecological virtuous cycle, and a harmonious operation of the human settlement environment. This paradigm focuses on the experience of human settlement and benign growth, and is based on the harmony of the natural system and the harmony between man and nature. Additionally, it features high efficiency, sound methods, efficient resource use, internal and external coordination, cyclic feedback, and innovation.

Following the natural eco-laws system of operation, prioritizing the area's resources, environment, and residents, and creating a creative, circular development model with input

from all the stakeholders, are all part of what an ecological operation for urban residential areas entails.

2.2. Identification and Classification of Stakeholders

Stakeholder theory originated from enterprise management, and was formally proposed by Stanford researchers in 1963. Among them, Freeman's definition of stakeholder is the classical one, and is, "any group or individual that can influence the realization of an organization's goals or is affected by the goals". This definition is also applicable to the field of ecological operation [31]. Identification is the starting point of stakeholder research. At present, in the classification of ecological operation stakeholders, the literature review method is used to preliminarily identify the ecological operation stakeholders; the four classification methods of government, community, enterprise and other groups are most used [32]. Secondly, a focus group [33] is established, including officials of the overall design and planning department of the ecological operation mode, an authoritative expert in the field of ecological operation research, and a young scholar in the field of ecological operation research. In line with the present situation of ecological operation and with the suggestions of experts in the focus group, 13 stakeholders in ecological operation were identified and further divided into 4 categories (Table 1).

Table 1. Main stakeholders and classification.

Classification	Stakeholders
Governments of all levels	S1 Central government S2 Provincial government S3 Local government (city and county governments and urban management committees)
Enterprises	S4 Development operators S5 Project management company S6 Service company S7 Major social capital partners, mainly real estate or joint development companies S8 Strategic investors such as financial institutions, represented by commercial banks and investment funds
Residents	S9 Neighborhood residents S10 Other beneficiaries
Social organizations (independent of government)	S11 Community grassroots self-governance organizations S12 Environmentally friendly social organizations S13 Social welfare service organizations

2.3. Research Methodology

2.3.1. Data Collection Process

The social network analysis method requires a different kind of data to the conventional statistical data type. Social network analysis data is the relationship data among actors, whereas the statistical data needs attribute data. This article's network of interest is a part of the broader network analysis. The methods used to acquire the data included expert interviews, surveys, and media reports. The expert questionnaire approach was chosen because experts have extensive field-related work experience, regular interaction with all stakeholders, and the ability to evaluate interest relationships objectively. Ten specialists in ecological operation planning and research were chosen for this purpose, based on four factors: whether or not they had carried out ecological operation research in conjunction with the focus group, their knowledge of the stakeholders, their level of project-planning experience, and whether or not they had submitted proposals or comments to the pertinent departments. Each expert's importance was assessed using the four factors. Each expert was expected to score and assess the connections between the 13 stakeholders in an ecological operation using the evaluation scale, and to weight the

evaluation scores of the other 10 experts. In addition, representatives of various stakeholders (Table 1) were interviewed, and pertinent media stories were gathered in order to further review the accuracy of the data from the 10 experts evaluations. The expert questionnaire was the primary approach used to obtain the relationship data, which was then adjusted by interviews and news-source information. The final data matrix of the ecological operation and stakeholder relationship-network was obtained after assessing the weighted average of the expert data. The relationship data among actors was the data type needed for the social network analysis method. The data values were 0, 1, and 2 [30], where 0 denotes the absence of any relationship of interest between stakeholders, 1 denotes a weak or general relationship of interest between stakeholders, and 2 denotes a strong or close link of interest between stakeholders. The interest relationship network data matrix, according to UCINET (University of California at Irvine NETwork), was converted into a network graph (Figure 1). This served as the foundation for the investigation of coherence, relevance, reciprocity, transmissibility, hierarchy, and agency [31].

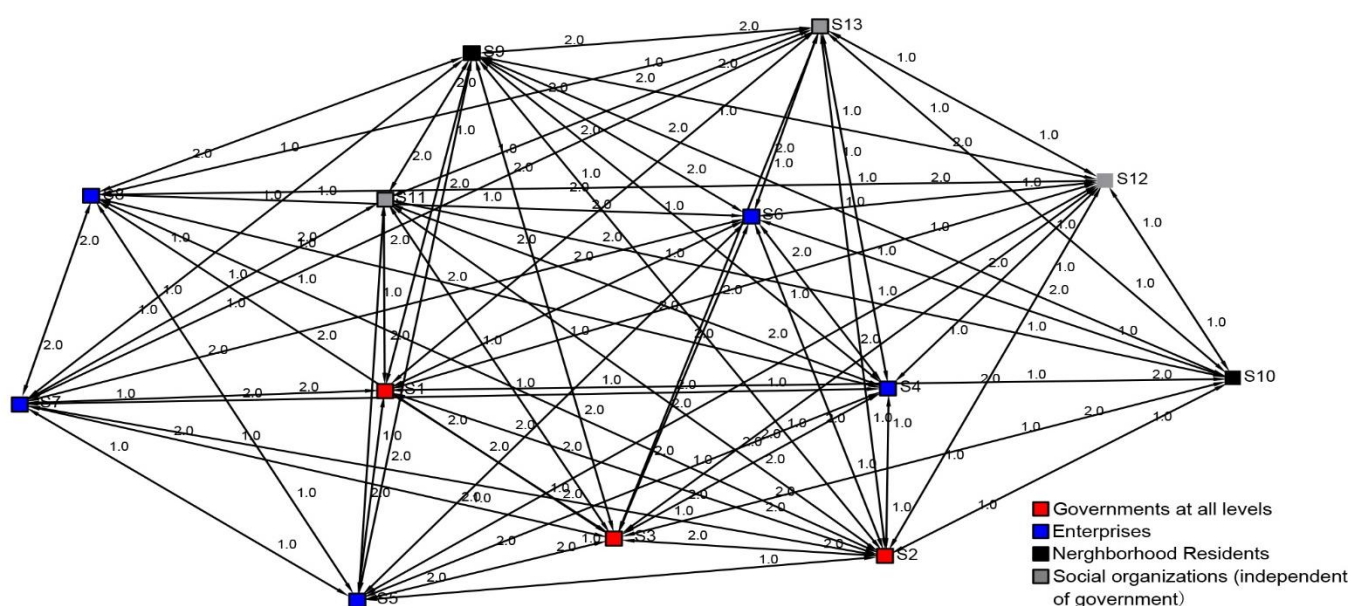


Figure 1. Interests relation network diagram.

2.3.2. Analysis Methods for Data

The social network professional analysis software UCINET6 was used to analyze the interest-network data using cohesion analysis, correlation, reciprocity and transferability, and the hierarchical and surrogate analysis methods; the index meanings of each method are as follows.

(1) Cohesion analysis

The study of intra-small-group cohesion among actors is referred to as cohesion analysis. In situations where intragroup cohesion is very high and intergroup cohesiveness is low, compared with intragroup cohesiveness, factions can form quickly. The density indicator and the E-I index (external-internal index) are the markers used to gauge this cohesion. Since the network data is a multi-valued directed network, the density index is calculated, and the closer a number is to 2 the more cohesion it shows. S is the total sum of all network relationships, and g is the total number of network nodes. The number of relationships between groups and the number of relationships within groups are used to generate the E-I index. The E-I index is a metric used to assess how closely connected the network's factions are. Its value ranges from -1 to 1 . The closer it gets to 1 , the smaller the faction is, and the relationships take place outside the group. The more it trends toward

−1, the more different factions there are in the network, and the relationships are focused within the factions.

(2) Relatedness analysis

The correlation analysis focuses on measuring the connection status among actors, which is measured by the point correlation matrix, that is, how many points need to be removed so that a point in the network cannot reach other points. The point correlation matrix is a cross-frequency table, and the higher the value, the higher the correlation between the two points. A high-relevance network has the characteristics of decentralized information, information dispersion, equal stakeholders, and not being easily influenced by other stakeholders, while a low-relevance network is the opposite.

(3) Reciprocity and transferability analysis

The reciprocal interaction between two network actors is mostly represented by reciprocity. This essay focuses on the relationships between and within four interest groups that are mutually beneficial. The reciprocal index, or the proportion of the reciprocal relationship coefficient to the total number of relationships, is the precise indicator. The value ranges from 0 to 1. The more the reciprocity within or between groups, the more strongly the value moves toward one.

Transitivity is the study of how interests and resources are transferred when three or more participants in a network are working together. High transmissibility is the ability to access and make use of resources for cooperation, information sharing, and communication. The clustering coefficient can be used to determine the transmissibility. The degree of clustering between vertices on a graph is described using the clustering coefficient. It is specifically the level of connection between a point's neighboring points. The calculation is as follows: clustering coefficient = number of triangles in the network with node a as their center / number of connected triplets with node a as their center. The value ranges from 0 to 1. The point's transitivity is stronger when the value is higher.

(4) Degree centrality analysis

In stakeholder relationship networks, centrality analysis focuses on the dominant power analyses within the network, focusing on the degree of power concentration within the relationship network, the degree of control over others, and the degree of control by others. The main measures are classified as degree centrality indicators, intermediary centrality indicators, and proximity centrality indicators.

Degree centrality is the sum of the number of actor relationships. If the network is directional, it can be divided into outward degree centrality and inward degree centrality. Outward degree centrality is the sum of the number of external relationships a node acknowledges, i.e., the degree to which you consider others important; inward degree centrality is the sum of the number of relationships other nodes acknowledge to a node, i.e., the degree to which others consider you important. An actor's degree is determined by the number of other players who are directly related to him as in-degree, and vice versa, in the case of a weighted and directed network on a graph. The metric determines the node size that the actor produces. The greatest value in degree centrality can produce the most influential actors, where d_i is the degree (number of adjacent edges) of the node v_i . It is calculated as

$$C_d(v_i) = d_i^n(\text{prestige}) \quad (1)$$

Betweenness centrality is a measure of the degree of control a node has over others. It is calculated as

$$C_B(n_i) = \sum_{j < K} g_{jk}(n_i) / g_{jk} \quad (2)$$

where g_{jk} is the number of shortcuts for node j to reach node k and $g_{jk}(n_i)$ is the number of shortcuts with node i on the node's shortcut to reach node k .

Closeness centrality is a measure of the extent to which a node is not controlled by others. The proximity centrality of a node is the sum of the shortcut distances of all other points in the network at that point. It is calculated as

$$C_c = \sum_{j=1}^n d_{ij} \quad (3)$$

where d_{ij} is the shortcut distance between points i and j (i.e., the number of shortest line segments between the two points)

(5) Generational Analysis

Through broker analysis, the generational analysis can determine “who” is significant in the stakeholder relationship network of ecological operations. The function of information transfer and communication coordination is carried out by brokers, who act as a “bridge” in the stakeholder relationship network. As such, they occupy a key intermediary position in the relationship network, and can take advantage of their advantageous location. There are five different kinds of brokers: liaison, coordinator, advisor, agent, and gatekeeper. The other three jobs are the brokers who coordinate the conflicts and disputes among stakeholder organizations, while the coordinator and advisor are the brokers who coordinate the conflicts and disputes inside the stakeholder organizations. Coordinator means that if A and BC are a part of the same group and B is an intermediary, then B is a coordinator; advisor is what B is referred to if A and C are in the same group and B is an interim member of another group; agent is a phrase used to describe B if B is an interim member, A and B are in the same group, and C is in a different group. Gatekeeper is what B is referred to as if B is an intermediate, B and C are in the same group, and A is in a different group; liaison denotes the situation where B is a middleman and A, B, and C are in distinct groups. The coordinator is the best person to handle interest disputes within the group, since she is an internal member of the interest group, has less time and money to spend, and is more familiar with the internal environment. The advisor can provide relative neutrality because he or she is not a part of the organization. Brokers known as gatekeepers and agents serve as insiders for outside interest groups, and are crucial for coordinating intergroup interests. The liaison, on the other hand, serves as a neutral party to help the other two parties’ interests be coordinated, which is critical for the other two parties but not important for the liaison’s interest group.

3. Results and Discussion

3.1. Result Analysis

3.1.1. Cohesiveness of Eco-Operational Stakeholder Relationship Network

Cohesiveness can be measured by the density index: the closer the index is to 2, the closer the network relationship is. On the whole, the density of the eco-operating stakeholder network is 1.3205, with a standard deviation of 0.6792, indicating that the stakeholder relationship is not tight and that the network members have a “tight-loose” pattern. Another dimension of cohesiveness is solidarity (E-I index); the E-I index takes a value between -1 and 1 , and the closer the value is to 1 , the more relationships tend to occur outside the group and the less factionalism there is; in the contrary situation, relationships are concentrated inside the group, resulting in factionalism. As can be seen from Table 2, the E-I indices of the four stakeholder organizations all range from 0 to 1, indicating that the interest relationships as a whole occur outside the group, and that there is no factionalism in the network.

All levels of government and resident parties have the highest density (value of 2) within stakeholder organizations, indicating that their internal interests are relatively close. Enterprises have the second-closest type of interests within the group, with a density of 1.75, and social organizations (independent of government) have the third-closest type of interests, with a density of 1.5, indicating that their internal members have average interests. Governments at all levels occupy a prominent place in the network, as shown

by the strong interest relationships that exist between them and businesses (1.467) and social groups (independent of government) (1.556) in terms of the relationships between stakeholder organizations. When Table 2 is added, it becomes clear that the core interest relationship is between all levels of government and settlement residents, pointing to within all levels of government and settlement residents, between all levels of government and enterprises (1.467), between all levels of government and social organizations (independent of government) (1.556), and between settlement residents and social organizations (independent of government) (1.5); the marginal interest relationship is between all levels of government and enterprises. The core-edge regression model in UCINET yielded findings of 1.556 for the core density, 0.833 for the edge density, and 0.723 for the difference between the two, demonstrating a distinct “core-edge” link between ecological operation stakeholders. This suggests that there is a clear “core-edge” relationship between those involved in ecological operations. In order to achieve the coordination of interests between core- and edge-relationships of stakeholder organizations, it is necessary to balance and increase communication and cooperation between edge groups and core groups.

Table 2. Density matrix and index E-I of Group level.

Density Matrix	Governments of All Levels	Enterprises	Residents	Social Organizations (Independent of Government)	Grouping Hierarchy E-I Index
Governments of all levels	2	1.467	1.167	1.556	0.667
Enterprises	1.133	1.75	1.3	0.8	0.286
Residents	1.333	1	2	1.5	0.818
Social organizations (independent of government)	1.444	0.733	1.667	1.5	0.647

3.1.2. Relevance of the Stakeholder Relationship Network for Ecological Operations

Through calculation, it is possible to remove at least 8 points from any point in this relationship network to make the point not connected to other points, and an average of 9.763 (standard deviation 1.042) points are removed from each point to disconnect all points, indicating that the ecological operation stakeholder relationship network as a whole has more intensive connections between points and a higher degree of correlation.

The stakeholder relationship network’s grouped average point correlation matrix is displayed in Table 3. When comparing it with Table 2, we can see that (1) the average point correlation within each level of government is the highest (11), with the highest density (value of 2), indicating that the interests within each level of government are close, relatively decentralized, and difficult to be influenced by other stakeholders; and (2) the average point correlation within the enterprise is the lowest (9.2), with an average density value of 1.75, indicating that enterprises have average in-house interests. (3) There is a medium average-point-association (10 between residents of settlements and social organizations that are not governed by the government), with the highest density of settlement residents (value of 2) and the lowest density of social organizations (value of 1.5). This demonstrates a closer relationship between the interests of social organizations and settlement residents, as well as a somewhat decentralized power structure, greater equality among stakeholders, and increased vulnerability to the sway of other stakeholders.

Table 3. Average point correlation matrix of the Interest relationship network.

Average Point Correlation Matrix	Governments of All Levels	Enterprises	Residents	Social Organizations (Independent of Government)
Governments of all levels	11 (0.373)	10 (1.258)	10.5 (0.5)	10.33 (0.471)
Enterprises	10 (1.181)	9.25 (0.994)	9.4 (1.02)	9.27 (0.998)
Residents	10 (0)	9.2 (0.748)	10 (0)	10 (0)
Social organizations (independent of government)	10 (0.994)	9.3 (1.075)	10 (0.687)	10 (0.687)

3.1.3. Reciprocity and Transferability of Ecological Stakeholder Relationship Networks

Table 4 shows that the reciprocity of the ecological operational stakeholder network is high. Reciprocity is high within each level of government, enterprises, settlement residents, and social organizations (independent of government) (all with a value of 1), and is also high between each level of government and the other three stakeholders, while reciprocity between enterprises and social organizations (independent of government) is relatively low (with a value of 0.7). This indicates that the ecological operation interest network has a very high-interest correlation both within and between groups.

Table 4. Group reciprocity of interest relationship network.

Reciprocity Index	Governments of All Levels	Enterprises	Residents	Social Organizations (Independent of Government)
Governments of all levels	1	0.867	1	1
Enterprises	1	1	0.75	0.7
Residents	0.833	1	1	1
Social organizations (independent of government)	1	0.7	1	1

The ecologically operated stakeholder relationship network's overall clustering coefficient was calculated to be 0.883, showing a comparatively strong transferability of the network's overall relationship structure. Table 5 displays the group average coefficients and point clustering coefficients for the four stakeholders. While the average clustering coefficient of all levels of government is the lowest, the average clustering coefficient of settlement residents is higher than the average clustering coefficient of the other three parties. It was discovered that the clustering coefficients of the four stakeholders were significantly different ($p < 0.05$) using the point-attribute ANOVA in UCINET, which shows that the transferability of settlement residents and social organizations (independent of government) as the apex differs significantly from that with all levels of government or enterprises as the apex, and that the transferability with settlement residents as the apex differs significantly from that with all levels of government, enterprises, and social organizations (independent of government). Therefore, it is essential to increase the governmental sector's transferability as the apex.

Table 5. Group clustering coefficient of interest relationship network.

Interest Group	Stakeholder	Clustering Coefficient	Average Clustering Coefficient
Governments of all levels	S1	0.871	0.863
	S2	0.864	
	S3	0.856	
Enterprises	S4	0.856	0.883
	S5	0.891	
	S6	0.864	
	S7	0.911	
Residents	S8	0.891	0.901
	S9	0.879	
	S10	0.922	
Social organizations (independent of government)	S11	0.871	0.89
	S12	0.909	
	S13	0.891	

3.1.4. Hierarchical Nature of the Stakeholder Relationship Network for Ecological Operations

Table 6 shows that there is no significant difference in the inward degree centrality and near-centrality of the stakeholder organizations in the stakeholder relationship network of ecological operation ($p > 0.05$), indicating that there is no significant difference in the overall power concentration of the stakeholder organizations and the absence of control by other stakeholders. However, each stakeholder organization's level of power varies greatly: (1) the provincial government, when compared to other levels of government, has the lowest inward degree centrality (13), but the highest near-centrality (20), indicating that it is in a significantly weaker and less powerful position and is susceptible to control by other stakeholders; (2) the main social capital partners among the businesses, primarily real estate or joint development businesses, have the lowest inward (2), the least centrality among enterprises (13), but close to the most centrality among enterprises (14), suggesting that they are in a weak and less strong position among enterprises, and are susceptible to the management of other stakeholders; (3) among residents of settlements, the lowest degree of centrality (14), but close to the highest degree of centrality (14), indicates that other beneficiaries are in a weak and less powerful position among residents of settlements in relation to the control of other stakeholders; (4) environmental protection and social welfare service organizations have the lowest degrees of centrality (13) among social organizations (independent of the government), but the highest degrees of near-centrality (13), indicating that they are in a weak and less powerful position among social organizations (independent of the government), and are easily influenced by other stakeholders.

Table 6. Centrality index of interest relationship network.

Interest Group	Stakeholder	Indegree	Betweenness	Closeness
Governments of all levels	S1	14	1.915	12
	S2	13	2.006	12
	S3	23	2.339	12
Enterprises	S4	20	2.339	12
	S5	14	1.349	13
	S6	16	1.936	12
	S7	13	0.424	14
	S8	15	1.081	13
Residents	S9	20	1.431	12
	S10	14	0.771	14
Social organizations (independent of government)	S11	18	1.589	12
	S12	13	0.758	13

The intermediary centrality of each stakeholder organization also differs significantly ($p < 0.05$), and settlement residents' intermediary centrality is lower than that of the other three. This difference indicates that settlement residents' ability to control other stakeholders is much lower than that of the other three stakeholder organizations. Moreover, the intermediation centrality of major social capital partners, mainly real estate or joint development enterprises, strategic investors such as financial institutions represented by commercial banks and investment funds, other beneficiaries, environmentally friendly social organizations, and social welfare service organizations are all low, indicating that the ability of these stakeholders to control other stakeholders is weaker.

3.1.5. Agency of Ecological Operation Stakeholder Relationship Network

The analysis of brokers can be used to fulfill the analysis of agency. Table 7 reveals that the coordinator position is absent in four stakeholder organizations, including the government, enterprises, inhabitants of settlements, and social organizations, from the standpoint of internal stakeholder disputes and conflicts, i.e., coordinator and advisor (independent of government). The facilitator of stakeholder organizations' internal relationships, the coordinator, is known for rapid coordination and low coordination costs.

Therefore, the coordinator plays a crucial role in helping to resolve internal conflicts and disagreements, and his or her absence will make it more difficult to resolve conflicts of interest within the government and enterprises, among residents of the settlement, and within social organizations (independent of the government) at all levels. The advisor role, which is also used to coordinate group interests, is not taken on by any governments, businesses, residents, or social organizations that are not part of the government at any level (the advisor role is absent from all four stakeholder organizations). Advisor roles are used to coordinate group interests within pressure groups. In conclusion, the analysis of the coordinator and advisor roles suggests that when disagreements and conflicts over interests develop throughout all levels of government, enterprises, settlement residents, and social organizations (independent of government), without the advisor and coordinator roles, there may be major interest conflicts that are impossible to address inside each organization. The coordinator is a “self-regulator” within the interest group; as a result, the coordinator is the best role to resolve conflicts within the interest group. In contrast, the advisor is an outsider, regulating the relationship within the interest group; as a result, while maintaining neutrality is an advantage, it has the disadvantages of slow coordination, high coordination cost, and poor coordination. The drawback of coordination is that it is unreliable, expensive, and inefficient.

Table 7. Frequency distribution table of interest group’s broker role.

Interest Group	Stakeholder	Coordinator	Gatekeeper	Representative	Consultant	Liaison	Total
Governments of all levels	S1	0	0	0	0	7	7
	S2	0	0	0	0	13	13
	S3	0	0	0	0	0	0
Enterprises	S4	0	0	0	0	0	0
	S5	0	2	4	0	0	6
	S6	0	0	3	0	0	3
	S7	0	0	3	0	0	3
	S8	0	3	3	0	0	6
Residents	S9	0	0	0	0	0	0
	S10	0	0	0	0	6	6
Social organizations (independent of government)	S11	0	0	0	0	2	2
	S12	0	1	1	0	3	5
	S13	0	2	0	0	3	5

According to Table 7, it can be concluded that (1) governments at all levels assume the greatest number of the three roles (20 times) in all stakeholder organizations combined, which indicates that governments at all levels coordinate interests between their own groups and external groups, as well as coordinating the interests of other stakeholder organizations, from the perspective of mediating conflicts and disputes among stakeholder organizations. This shows that governments at all levels hold a dominant intermediary position in coordinating their own group’s interests with those of external groups, and in coordinating the interests of other stakeholder organizations in addition to their own group. This can present opportunities for governments at all levels to control members of other stakeholder organizations and thus gain brokerage benefits; (2) companies take on the roles of gatekeeper and agent 18 times, excelling in the agent role, demonstrating that they also possess a strong competitive position in harmonizing the interests of stakeholder groups, and so benefit from brokerage by relying on the intermediary; (3) social organizations play a key role in coordinating relationships among stakeholder organizations other than their own, taking on the liaison role 12 times (gatekeeper three times, agent one time, and liaison eight times); (4) settlement residents are weaker, playing the liaison role six times, indicating that settlement residents are in a marginal position in the overall stakeholder network.

3.2. Discussion

Based on the social network analysis method, it can be seen that the overall network interest relationships are relatively balanced; there is no obvious faction forest, the degree of relevance is high, and the transitivity and reciprocity is high, but the overall power is relatively decentralized, and all participating parties have equal access to information. Conflicts and disputes inside an organization can never be resolved quickly.

4. Conclusions and Recommendations

4.1. Conclusions

On the whole, the stakeholders of ecological operation are mainly weak, and there is no faction, but there is a core-edge" structure relationship; the relationship network has the characteristics of high relevance, high reciprocity and high transferability; the overall power of the network is relatively decentralized, but the power within each group is concentrated; the government at all levels has strong control, while the residents of the settlement and social organizations (independent of the government) are in a weak position, with the following specific findings.

4.1.1. Cohesiveness

The overall network of stakeholder relationships in ecological operations is dominated by weak interest-relationships. This is not conducive to communication, coordination, and cooperation among stakeholders, and is not conducive to the realization of the ecological operation model. The relationship between social organizations (independent of the government) and enterprises is the weakest link in the network, and the relationship between them needs to be strengthened.

4.1.2. Relevance

The total network of stakeholder interactions in ecological operations has a high degree of relatedness, and is densely connected between sites. Together with the density analysis in Table 2, it is clear that (1) while there are close ties between the interests at each level of government, sectoral synergy is insufficient, and the respective jurisdictions of the federal and provincial local governments are somewhat fragmented. Governments at all levels have a disproportionately high density of relationships with businesses, settlers, and non-governmental social organizations, suggesting that they are more connected to the other three parties; (2) enterprises have a broad range of internal interests, more concentrated power, and are susceptible to pressure from outside stakeholders. Additionally, there is a lack of a strong relationship between businesses and settlement residents, as well as between businesses and non-governmental social organizations; however, there is a strong connection between residents of settlements and non-governmental social organizations, with relatively decentralized power, equally-sized stakeholders, and the potential for sharing and cooperation. There is a chance for cooperation and sharing.

4.1.3. Reciprocity and Transferability

The ecological operation stakeholder relationship network is characterized by high reciprocity and high transferability, which is conducive to opportunity sharing and resource transfer. Combined with the density analysis in Table 2, it is clear that this relationship network as a whole is dominated by weak interest relationships, high reciprocity, and high transferability. (1) Reciprocity dimension: (i) high reciprocity and strong interest relationships within all levels of government, among all levels of government and enterprises, settlement residents, and social organizations (independent of government), which are conducive to coordination and cooperation among stakeholder organizations in conducting ecological operations; (ii) high reciprocity and weak interest relationships between enterprises and social organizations (independent of government), and between enterprises and settlement residents, which are not conducive to later. This is not conducive to the maintenance of the results of ecological operation. (2) Transferability dimension: the

ecological operation stakeholder relationship network is a reciprocal network, with high transferability. Due to the specificity of the settlement residents' group, its transferability is higher than that of the other three parties. However, at the same time, the transferability with government departments at the apex needs to be improved.

4.1.4. Hierarchical Nature

The power within each stakeholder organization is more consolidated, despite the decentralized nature of the eco-operational stakeholder relationship network's overall power. (1) In the overall relationship network, settlement inhabitants are in a disadvantaged position in terms of decision-making power, voice, and benefit distribution, since their ability to influence other stakeholders is much weaker than that of other interest groups in the total relationship network. (2) In the group's internal relationship network: (i) the power status of stakeholders in government departments varies greatly, with provincial governments being comparatively weak, less strong, and easily managed, and their control ability is poor as a "key bridge" between the central government and local governments; (ii) settlement residents have less authority over other stakeholders, and are weaker and less influential, and ineffective at managing other stakeholders. Other beneficiaries have a weak ability to control other stakeholders among themselves; (iii) among businesses, the main social capital partners, primarily real estate or joint development businesses, have less power, are susceptible to control, and have a weak ability to control other stakeholders; among social organizations (independent of the government), environmental protection social organizations and social welfare service businesses have less power, are susceptible to control, and have a weak ability to control other stakeholders; (iv) among non-governmental social groups, environmental and social welfare service organizations have less influence, are more susceptible to manipulation, and are less able to control other stakeholders.

4.1.5. Agency

(1) Within the dimension of coordinating the relationship within the ecological operation stakeholder organizations: (i) governments at all levels, enterprises, settlement residents and social organizations (independent of the government) lack the role of coordinator and advisor, and the conflicts and disputes within the organizations cannot be solved in time, which may lead to conflicts; (ii) development operators lack coordinator and advisor roles, both of which may become the triggers for interest disputes and conflicts. (2) Within the dimension of coordinating the relationship between stakeholder organizations of the ecological operation: (i) residents of the settlement are at the edge of the overall interest relationship network; (ii) enterprises and social organizations (independent of the government) are at the secondary dominant middleman position, and both of them are outstanding in coordinating the relationship among other stakeholder organizations outside their organizations, and can rely on their advantageous position to obtain benefits; (iii) governments at all levels occupy the dominant intermediary position, and therefore, governments at all levels have more control and can control members of other interest groups, to obtain brokerage gains.

4.2. Recommendations

(1) In order to achieve the shift from weak to strong interest ties, it is important to clarify roles, enhance connections, and work to reverse the "core-fringe" relationship pattern of stakeholders in ecological operations. (i) It is necessary to describe the functions of all levels of government in the ecological operation. Although they do not directly participate in the ecological operation, the central or provincial governments create or amend macro policies, and oversee the implementation of such policies at the local level. Local governments are still in charge of making decisions, and are in charge of coming up with logical answers. The government should actively foster a relaxed market atmosphere, give authority to businesses and social organizations, and refrain from interfering with business management throughout the actual operating process, while stimulating the vitality of

social organizations and the enthusiasm of settlement residents. For instance, in the actual ecological operation, the government must both pay attention to the interests of businesses and monitor the ecological growth in daily settlements. Businesses, residents, and social groups urgently require the government's support, especially in light of the recent pneumonia outbreak, and a "strong relationship" reflects "genuine caring." (ii) It is important to strengthen the complex relationship between social organizations and businesses. To raise awareness of energy conservation and emission reduction among operators and residents in residential areas, infrastructure builders and operators in those areas should, for example, pay attention to the opinions of local self-government organizations and environmental protection organizations; government departments should direct public welfare service organizations to pay attention to the public welfare activities of residents in residential areas. In addition, the interests can be stabilized through a sound communication mechanism, sharing mechanism, and cooperation mechanism, to ensure the collaborative governance of multiple subjects.

(2) From the perspective of correlation, we should optimize the correlation among the stakeholder organizations of the ecological operation, and strengthen the synergy within each organization. (i) Government departments, firstly, should improve the communication and coordination mechanisms between governments at all levels, to avoid departmental constraints, through the coordination of government departments of safety, firefighting and transportation in the actual operation process; secondly, there should be improvement of the correlation between governments at all levels and residents of the settlement and social organizations, such as the coordination of government departments in the operation process. (ii) Enterprises, firstly, strengthen the connection between the interests of the enterprises, and strengthen the connection between development operators, project management companies, service companies and investment companies. They have absolute influence and power in the actual operation process. Their performance is linked to the actual operating performance and has high-interest demands. In addition to developing and operating according to ecological key indicators, they also need to consider ecological low-carbon, intelligent health, and technology costs. Secondly, it is necessary to improve the linkage between enterprises and social organizations, such as communication with community grassroots self-governance organizations, environmental protection-oriented organizations, and social welfare service organizations. (iii) Settlement residents and social organizations, firstly, enhance the dominance of settlement residents and concentrate the overall power of settlement residents and other beneficiaries, who, as actual beneficiaries, are highly cohesive and enthusiastic about participation. Secondly, to enhance communication channels and realizes all-round connections with social organizations. Social organizations are initiated from the bottom up, and better understand the needs of the public. Compared with the management of government departments, they are concerned with the implementation of green concepts such as environmental protection, energy conservation, emission reduction, and the harmonious coexistence of humans and nature in real life in a micro and direct way. These social organizations are often more closely connected with grassroots government organizations, through which they can monitor and influence the implementation of government policies, while grassroots government organizations can also implement common governance and accomplish public affairs, by supporting the activities of social organizations.

(3) From a reciprocity standpoint, we fully exploit the weak relationship, high reciprocity, and high transferability properties of ecologically operated interest networks, to encourage the sharing of investment opportunities, information resources, and ecological culture among interest organizations, ensuring the interests of businesses and settlers, and taking into account the interests of social organizations. A strong relationship with high reciprocity and high transferability gradually replaces the weak relationship with high reciprocity and high transferability in the ecological operation benefit network, as a result. From the standpoint of transferability, we strengthen the transfer of interests between groups with government departments as the apex, strengthen the leading role of

government departments, build a stakeholder cooperation mechanism under the leadership of government departments, and improve communication channels and cooperation platforms within government. Through the exchange of interests, channels of communication, and procedures for cooperation, the “core-fringe” relationship structure between ecological operation stakeholders is dismantled. The transfer of interests between groups with government agencies as the apex must be strengthened in the early stages; in the later stages, the transfer of interests between groups with businesses and residents as the apex is particularly crucial. On the basis of this, a long-term governance model and mechanism for the sustainable growth of ecological operations should be built.

(4) From the perspective of hierarchy, there is a need to strengthen the participation and voice of settlement residents and social organizations, and optimize the power structure within government departments. (i) Governments at all levels, firstly, stimulate the initiative of local governments to actively participate in the process of ecological operation, both in the public interest in order to maintain equality, justice, and a stable social environment to meet the spiritual and cultural needs of residents, and also following national development. (ii) Residents, to enhance their participation, voice and influence, and to ensure equal opportunities and rights for residents’ participation. (iii) Enterprises, to enhance the voice of development operators, project management companies, and service companies, and to lay a solid foundation for the implementation of the ecological operation. (iv) Social organizations, such as grassroots community self-governance organizations, pay close attention to the actual operation and mobilize residents and enterprises to participate in the governance and sustainable ecological development of settlements through their influence, to compensate for the government’s lack of management, insufficient funds and information asymmetry in the operation process.

(5) From the perspective of agency, the government plays a leading role in coordinating the relationship between stakeholder organizations, and focuses on the basic role of self-regulation within interest groups, to build a governance system of “active government, effective market, and organic society”. (i) Governments at all levels, firstly, should cultivate the role of coordinator and advisor, and at the same time restrain the power of government departments, and guard against the tendency of “big housekeeping government”; secondly, they should pay great attention to the internal and external relations of development operators, project management companies and service companies, to avoid conflicts of interest. (ii) To cultivate the role of gatekeeper, agent, liaison, and play the role of guide and “bridge” to resolve the conflicts and disputes between social organizations and governments at all levels, and between social organizations and enterprises. The residents are the actual beneficiaries of the ecological operation, and it is conducive to the good operation of the ecological operation model to maintain a harmonious and smooth relationship between them and the governments and enterprises, at all levels.

4.3. Summary

The relevant analysis examines the stakeholder characteristics and relationship network structure in the ecological operation, assesses stakeholder relationships, and proposes countermeasures and recommendations for improving relationships and collaborative governance, which will aid in the implementation of the ecological operation mode. Building a harmonious environment for human settlement, realizing the harmony of man and nature, and achieving sustainable growth of residential areas are all very important at the same time. The focus of subsequent research will, however, be on how stakeholders use the relationship network to seek out and gain benefits. In fact, the creation and growth of the interest relationship network is complicated for a particular model such as an ecological operation, and the characteristics of the network structure and the interest game process are dynamic. The focus of the next research in this area will be on examining how the relationship network structure has changed over time, how interest subject games have changed, and how strategies have been optimized. Additionally, the modernization of China’s governance system and capability involves the collaborative governance of many

subjects under the leadership of the government, and therefore it is important to consider carefully how to direct and integrate pertinent government departments.

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