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# The Evolution of the Collaborative Environmental Governance Network in Guizhou Province, China

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**Abstract:** China has successively set goals of carbon peaking and carbon neutrality, aiming to transform to a green and low-carbon economy. Collaborative environmental governance (CEG) is an important way to achieve this transformation. To improve collaborative environmental governance, the study of the evolution of the collaborative environmental governance network (CEGN) is necessary. In this study, the CEGNs in different periods in Guizhou Province, China are established based on social network analysis. Then, the evolution of environment governance policy implementers' functions in the network is investigated by two-dimensional (breadth and intensity) matrices. Moreover, the evolution of core implementers' functions and its impacts on the operation of the network are analyzed based on the network stability. The results show that the network size, frequency of collaboration, and cohesion have gradually increased, and the network structure has changed from a loose pattern to an expanded and balanced system. Implementers such as the governments of municipalities (prefectures) (MGs) and counties (districts) (CGs), urban management committee (UMCs), and municipal (prefecture) ecological environment bureaus (MBEEs) have played leading and coordinating roles at different phases. However, the cohesion of the network is low, indicating a low level of collaboration. This study integrates the collaborative governance theory and social network analysis, which provides a new way for the study of CEG. In addition, the CEG effect is evaluated by analyzing the evolution of the CEGN, which provides a reference for the CEG policy making in developing regions.

**Keywords:** collaborative environment governance; network evolution; policy implementer; social network analysis; ecological environment; two-dimensional matrix



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## 1. Introduction

Green and low-carbon development has gradually become an inevitable trend in global economic and social development, and how to coordinate the contradiction between economic development and environmental protection has become a prominent problem. To combat climate change, many countries have set various carbon emission reduction goals through legislation and policy formulation. China has proposed peaking carbon dioxide emissions before 2030 and achieving carbon neutrality before 2060 [1]. This marks China's official entry into the carbon-reduction era [2]. As an important ecological protection pilot zone and a demonstration plot of the Western Development strategy, Guizhou Province shoulders the mission of building a national green barrier and a green economy. Therefore, Guizhou's environmental governance demonstrates the level of China's ecological protection. In the past decades, there was a serious conflict between socio-economic development and environmental protection in Guizhou, and constraints such as ecosystem

degradation, environmental pollution, and resource scarcity greatly restrained its development [3]. To solve this problem, collaborative governance, which can increase the linkage and coordination between different regions and different subjects, has been established for environmental governance [4]. On 22 April 2022, the *Opinions on Promoting the High-quality Development of Nature Reserves with Guizhou Characteristics* issued by Guizhou Province points out that governments play a leading role in the governance and protection of natural environments, and a natural environmental protection system including governments, enterprises, environmental protection organizations, and the public will be established. To achieve CEG, formulating environment governance policies (EGP) according to local conditions and improving implementation are necessary [5]. However, under the collaborative governance context, the formulation and implementation of EGP require the coordination and unification of policy implementers [6,7].

At present, research on collaborative environment governance policy (CEGP) implementers mainly focuses on the following two aspects: Firstly, the collaborative governance model, coordination mechanism, etc., are qualitatively studied based on case study and theoretical models. For example, Yi [8] conducted a comparative analysis of the CEG models from the perspective of responsibility, policies, and technological innovation. Gerling and Yu [9,10] constructed a pluralistic co-governance model of urban environmental governance, and proposed a new win-win co-governance pattern between governments, enterprises, and citizens. At present, the CEG faces problems such as fragmentation of EGP, unclear division of powers and responsibilities, and low public participation [11,12]. Therefore, some scholars constructed regional CEG models from the perspectives of synergetic theory, cross-departmental governance, polycentric governance, etc. [13–17], and proposed countermeasures [18,19]. Secondly, the CEGN characteristics and evolution and collaborative governance effect are explored through quantitative analysis [20,21]. For example, Farr [22] used social network analysis to study the environmental protectors' network characteristics in Colorado, USA, and quantitatively analyzed the evolution of protectors' roles and network structure. Carattini [23] used network analysis to study the characteristics of international environmental protection collaboration, and found that the collaboration network was increasingly dense and cohesive, which facilitated policy coordination and knowledge diffusion. Yang [24] constructed a CEG effect evaluation model based on the DPSIR (driving force-pressure-state-impact-response) framework, and determined the evolution trend of the CEGN in Suzhou-Wuxi-Changzhou Megalopolis, China.

The formulation and implementation of EGP are driven by multiple factors in Guizhou, and the implementers are diverse [25]. The environment governance has evolved from relying solely on administrative punishment to the combining of market mechanisms, rewarding and punishing, etc. [26,27], and the objective gradually shifts from environmental protection to the coordinated development of economy, society, and natural environment [28,29]. However, the diversification of policy tools and the continuous optimization of objectives require increases in EGP implementers and functions. At present, the EGP implementers are centralized in Guizhou, but the roles of implementers are different in different EGPs. Therefore, it is impossible to grasp their role and function changes from an overall perspective [30]. The implementers who come from policy-making groups, cross-regional polycentric governance communities, inter-government networks, etc., directly determine the CEG effect. Therefore, the analysis of them to present the characteristics of the CEGN and the law of network evolution and functional transformation is of great significance for collaborative governance [31,32]. This helps break the environment governance bottleneck, improves collaborative governance efficiency, and promotes local green development.

It can be seen that previous studies pay much attention to the collaborative governance network and the mechanism, but few studies have explored the evolution of the collaborative governance network at different periods, resulting in limited practicability and generalization of the research results. Therefore, this study takes Guizhou Province of

China as a sample, uses social network analysis to establish the CEGNs including CEGP implementers at different periods, and comparatively analyzes the phase characteristics of the network. in addition, the two-dimensional (breadth and intensity) matrix is used to identify the evolution of the roles of implementers, especially the core implementer, in the network. This can help to correctly evaluate the CEG effect in Guizhou, and also provide practical support for the formulation of green development policies.

## 2. Materials and Methods

### *2.1. Social Network Analysis*

Social network is formed by the relationships (lines) between participants (nodes). It can be divided into individual network, local network, and overall network, and the overall network is the focus of current social network research at home and abroad. Using matrices and sociograms, the social network analysis can predict the behaviors and decision-making of nodes in the network, as well as the evolution of node interactions by centrality analysis, cohesive subgroup analysis, core-periphery analysis, and embedding analysis [33,34].

Usually, UCINET software (University of California at Irvine Network) is used to measure the centrality of data, construct stochastic dyad models, and conduct clique analysis [35]. This study uses the UCINET6.0 software to analyze the data. The study takes CEGP implementers as nodes, and environmental governance policies as lines, to construct networks. The network structure is evaluated by network scale, network connectivity, number of relationships, and cohesion index. The evolution of nodes' roles is analyzed based on the two-dimensional (breadth and intensity) matrix.

### *2.2. Data Acquisition and Processing*

The policy documents officially released by Guizhou Province since 2005 were collected from the Peking University Magic Weapon Database (https://www.pkulaw.com/; accessed on 20 December 2020). The search keywords were determined according to the connotation of the CEGP, the environment governance legal system, and the ecological protection in Guizhou Province, including ecological environment, environmental governance, ecological protection, green economy, etc. Finally, a total of 645 policies and laws were retrieved, and 214 valid data were obtained after removing expired, modified, and irrelevant policies and laws. In addition, 57 policies were collected from the official website of the Guizhou Department of Ecology and Environment. In the end, 271 policies and laws were collected.

The data statistics results show that the non-provincial (regional) level policies account for 43.91% of the total (Figure 1). This indicates that regional governments formulate many EGP in Guizhou Province. However, regional-level judicial and legislative regulations account for only 3.32%. This indicates that the formulation of environmental protection laws needs to be strengthened. The implementers mainly include governments, enterprises, the public., etc. Of the 271 policies and laws, 261 mention government departments (Guizhou Provincial Government, Provincial Department of Ecology and Environment, Provincial Environmental Protection Department, and Municipal Government), 16 policies mention enterprises, and 8 policies mention the public (schools, municipal (prefecture) patriotic health offices, and municipal (prefecture) labor unions). This shows that governments play a main role in the CEG in Guizhou, while the participation level of the public, enterprises, and non-profit organizations is low. A solid CEGN has not been established.

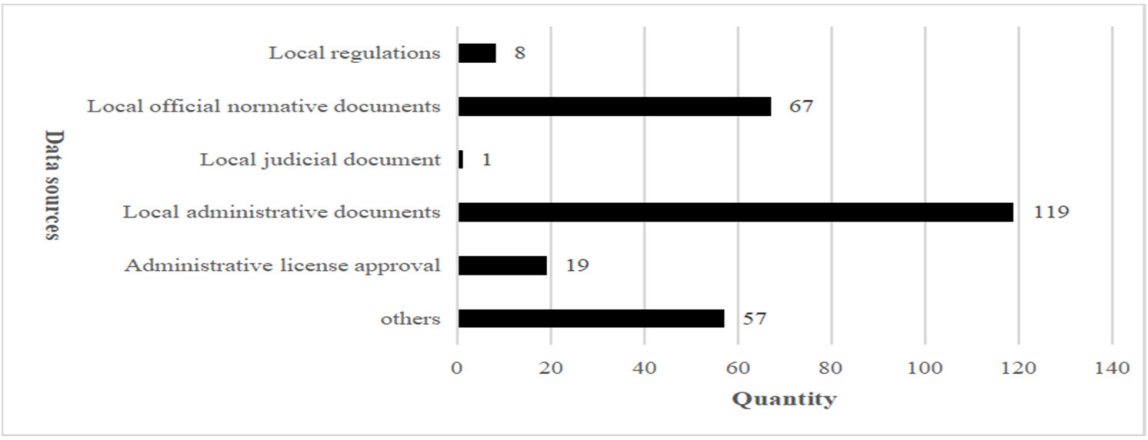



**Figure 1.** Statistics of environment governance policies in Guizhou Province.

### *2.3. Phasing*

To achieve coordinated development of economy, society, and environment, many environmental governance policies have been formulated and implemented. Since 2005, Guizhou Province has actively responded to the call of the State Council of China that the economic and social development must be coordinated with environmental protection, and listed environmental protection as one of the important development strategies. After nearly two decades, the number of environmental protection policies formulated by Guizhou Province have obviously increased. Based on the categorization of the objectives and characteristics of 271 policies, the evolution of the CEGP network in Guizhou Province can be divided into four phases (Table 1).

**Table 1.** Phases of collaborative environment governance in Guizhou Province.

| Time | Important Policy Document | Phase |
|---|---|---|
| 2005 | *Notice of the General Office of the People's Government of Guizhou Province on Establishing the Provincial Joint Conference System for Environmental Protection* | Start-up phase (2005–2009) |
| 2010 | *Detailed Standards for Discretionary Power of Administrative Penalties for Environmental Protection in Guizhou Province (Provisional)* | Strengthening phase (2010–2015) |
| 2016 | *Environmental Quality Consultation System of the Department of Environmental Protection of Guizhou (Trial)* | Transition phase (2016–2019) |
| 2020 | *Implementation Opinions of Guizhou Province on Building a Modern Environmental Governance System* | Systemization phase (2020–) |

Startup phase (2005–2009). The issuance of the *Notice on the Establishment of the Joint Conference System for Environmental Protection in Guizhou Province* marks the formal establishment of collaborative environmental governance in Guizhou Province, followed by the formulation of a series of policies and regulations. These aim to protect natural environment and improve environmental quality by strengthening coordination between CEGP implementers through the joint conference system. At this phase, the contents of CEG are scattered in comprehensive environmental protection policies. The main objective is to prevent and punish illegal acts and ensure environmental safety.

Strengthening phase (2010–2015). Taking the State Council's promotion of administration according to law as an opportunity, the punishment standards and coordinated governance policies are refined. During this phase, the Environmental Protection Department of Guizhou Province refined environmental protection laws and regulations involving fines, and normalized the discretion of environmental administrative penalties. Therefore, the type and number of relevant policies increase gradually, and improving the administration of environmental protection departments according to law is the main goal.

Transition phase (2016–2019). More and more implementers are included in the CEG. The establishment of the Environmental Quality Consultation System in Guizhou Province illustrates the main objective at this phase as the adjustment of the management system of environmental protection departments and the clarification of environmental protection responsibilities.

Systematization phase (2020–). The systematization of CEG is promoted to build a comprehensive and scientific environment governance policy system and achieve efficient environmental governance. The main objective at this phase is to strengthen the leading role of government departments, enhance the role of enterprises, and expand the role of social welfare institutions and the public to build a solid CEGN. This phase has a clear orientation, and is characterized by multi-party participation. Especially, an innovative, diversified, and coordinated environment governance model is formed.

## 3. Results and Discussion

### *3.1. The Evolution of the Collaborative Environment Governance Network*

#### 3.1.1. Collaborative Network Characteristics and Evolution

The co-occurrence matrix involving the policies and the implementers at each phase is constructed using the UCINET6.0 software (Figure 2). The node size represents the number of implementers. The larger the node, the more implementers. The isolated nodes without connections indicate that the implementer has no collaborative relationship with other implementers. The thickness of lines represents the frequency of collaboration. The thicker the lines, the higher the frequency.

#### 3.1.2. Phase Characteristics and Network Evolution Analysis

Based on the four phases, this study selects sample size, network size, number of network relationships, connection frequency, and cohesion index to quantify the network evolution (Table 2). The sample size represents the total number of CEG policies issued in each phase. The network size represents the number of implementers mentioned in the policies of each phase. The number of network relationships represents the number of connections between implementers. The connection frequency represents the frequency of collaboration of the implementers. The cohesion index represents the degree of collaborative governance between implementers.

**Table 2.** Characteristics of the collaborative environment governance network in Guizhou Province, China.

| Index | 2005–2009 | 2010–2015 | 2016–2019 | 2020– |
|---|---|---|---|---|
| Sample size | 21 | 75 | 104 | 46 |
| Network size | 11 | 19 | 38 | 44 |
| Number of network relationships | 7 | 23 | 97 | 140 |
| Connection frequency | 24 | 104 | 300 | 206 |
| Cohesion index | 0.436 | 0.608 | 0.427 | 0.218 |

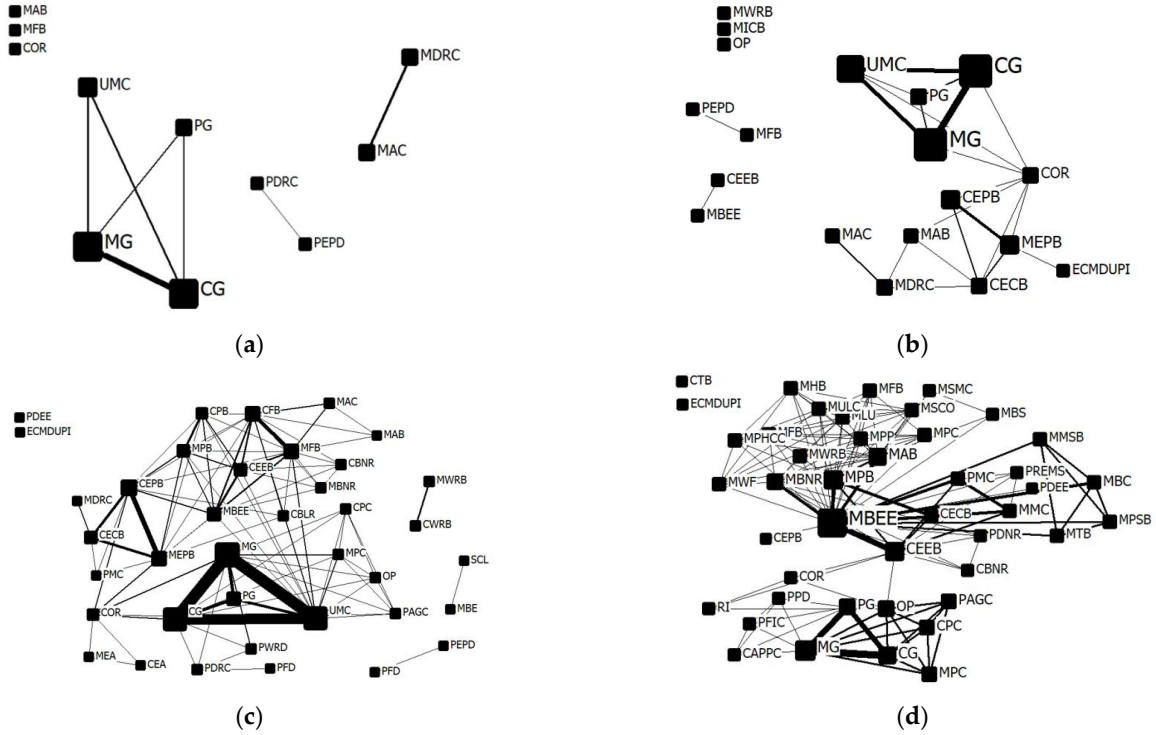



**Figure 2.** Collaborative environment governance networks in Guizhou Province, China since 2005. (**a**) 2005–2009 (**b**) 2010–2015 (**c**) 2016–2019 (**d**) 2020–. PEPD, Provincial Environmental Protection Department; PG, Provincial Government; MG, Municipal (Prefecture) Government; CG, County (District) government; PDRC, Provincial Development and Reform Commission; MDRC, Municipal (Prefecture) Development and Reform Commission; UMC, Urban Management Committee; MAB, Municipal (Prefecture) Agricultural Bureau; MFB, Municipal (Prefecture) Forestry Bureau; MAC, Municipal (Prefecture) Agricultural Commission; COR, Enterprise; MBEE, Municipal (Prefecture) Bureau of Ecological Environment; CEEB, County (District) Ecological Environment Bureau; MFB, Municipal (Prefecture) Finance Bureau; CECB, County (District) Ecological Civilization Bureau; MWRB, Municipal (Prefecture) Water Resources Bureau; MICB, Municipal (Prefecture) Industry and Commerce Bureau; ECMDUPI, Energy Conservation Management Department of Urban Public Institutions; OP, People's organizations; PDEE, Provincial Department of Ecology and Environment; PMC, Provincial Environmental Monitoring Center; PFD, Provincial Finance Department; CFB, County (District) Finance bureau; MBNR, Municipal Bureau of Natural Resources; CBNR, County Bureau of Natural Resources; MEA, Municipal (Prefecture) Energy Authorities; CEA, County (District) Energy Authorities; MPB, Municipal (Prefecture) Planning Bureau; CPB, County Planning Bureau; PWRD, Provincial Water Resources Department; CWRB, County (District) Water Resources Bureau; CBLR, County (District) Bureau of Land and Resources; PAGC, Party Committee of the Provincial Military Region and Armed Police of Guizhou Province; MPC, Municipal (Prefecture) Party Committee; CPC, County (District) Party Committee; PFD, Provincial Forestry Department; MBE, Municipal (Prefecture) Bureau of Education; SCL, School; MMC, Municipal (Prefecture) Environmental Monitoring Center; PDNR, Provincial Department of Natural Resources; CTB, County (District) Tax Bureau; PREMS, Provincial Radiation Environment Monitoring Station; MBC, Municipal (Prefecture) Bureau of Commerce; RI, Research Institute; MPSB, Municipal (Prefecture) Public Security Bureau; MTB, Municipal (Prefecture) Transportation Bureau; MMSB, Municipal (Prefecture) Municipal Supervision Bureau; PPD, Provincial Propaganda Department; CAPPC, Cyberspace Administration of the Provincial Party Committee; PFIC, Provincial Federation of Industry and Commerce; MPHCC, Municipal (Prefecture) Patriotic Health Campaign Committee; MSCO, Municipal (Prefecture) Spiritual Civilization Office; MHB, Municipal (Prefecture) Health Bureau; MLU, Municipal (Prefecture) Labor Unions; MULC, Municipal (Prefecture) Youth League Committee:; MWF, Municipal (Prefecture) Women's Federation.

The network size expands over time, changing from a decentralized pattern to a centralized pattern. In the startup phase, there are only 21 CEG policies, which are issued by 11 departments. However, at the transition phase, there are 104 CEG policies, which are issued by 38 departments. in addition, the number of network relationships and the connection frequency also increase over time. This indicates that the intensity of communication and collaboration has gradually increased. The cohesion index gradually rises, but its value is always lower than 0.15. According to the standard of Liu (2018), the cohesion is at a low level, that is, the collaboration level between implementers is low. This is consistent with the findings of [3,25]. This indicates that at this phase, the construction of ecological civilization in Guizhou still has a long way to go, and the pattern of multi-party participation has not yet taken shape.

In the startup phase, with the implementation of *the Strengthening of Environmental Protection and the In-depth Implementation of the Scientific Outlook on Development* in Guizhou, environmental governance assignments are collaboratively made, CEG project is launched, and a joint conference system for environmental protection is established. During this phase, 27% of implementers are isolated nodes in the network, and enterprises and non-governmental organizations are not involved. This indicates a weak CEGN with few types of implementer. In addition, the connection frequency is also low, indicating a lack of communication and cooperation. Therefore, during this phase, the CEGN is in a loose pattern. This is due to the combined effect of Guizhou Province's natural conditions, historical factors, and economic development [27,29]

In the strengthening phase, with the formulation and implementation of environmental protection regulations under national guidance, Guizhou Province strengthens the ecological environment protection by issuing a series of policies. A total of 75 policies are released in this phase. In addition, the number of implementers and network relationships obviously increase, the connection frequency increases by more than 4 times, and the cohesion index increases by 0.172, compared with those in the previous phase. This indicates a high-frequency and high-level collaboration. In addition, the node size is the largest of the four phases. This may be due to the fact that enterprises participate in the CEG and play an important role in this phase. In addition, Guizhou Province has continuously promoted the construction of ecological civilization and innovation in institutional mechanisms, and issued a number of laws and regulations to provide institutional guarantees for the construction of ecological civilization [3,28]. The network characteristic is partial equalization in this phase.

In the transition phase, with the increase in environment governance policies, more and more entities are included in the CEG. To improve the environment quality, Guizhou Province shifts from the pursuit of environmental quality to overall environmental management, and formulates 104 policies. At this phase, the types of environment governance policies increase, and multiple entities (38) participate in the CEG. The network is systematic, efficient, centralized, and balanced. The sample size, network size, number of network relationships, and connection frequency increase. This indicates a high level of collaborative governance in this phase. However, the cohesion index decreases at this phase. This indicates that although there is a high frequency of collaboration, the overall intensity still declines due to the participation of increased entities. This is the result of Guizhou Province making full use of the policy advantages of the Ecological Civilization Pilot Demonstration Zone, taking the lead in experimentation, boldly innovating, and doing a good job in the top-level design of provincial environment governance within the framework of national-level laws and regulations.

In the systematization phase, with the establishment of a modern environmental governance system in Guizhou Province and the evolution of the goal of the National Ecological Civilization Pilot Zone construction, the types of CEG policies increase, and the implementers pay much attention to overall coordination. During this phase, the network shows the characteristic of overall stability and regional coordination. Of the indicators, the network size and the number of network relationships continue to grow, reaching 44 and

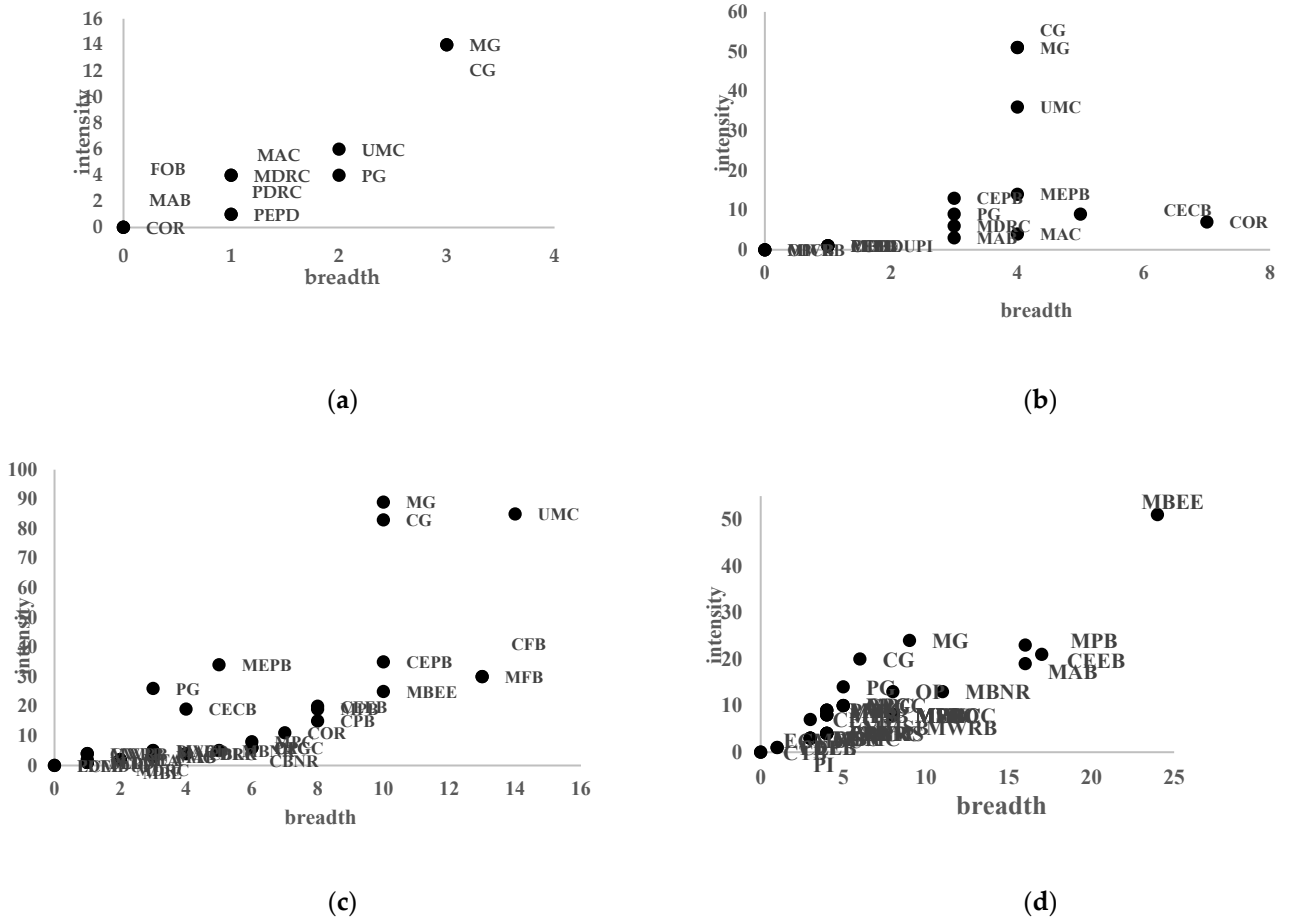
140, respectively, the frequency of connection is 206, the isolated nodes are few. In addition, the cohesion index decreases to 0.218. This indicates that the information exchange and collaboration between implementers are obviously improved at this phase, and the overall collaboration effect is enhanced. This may be due to that Guizhou has introduced market mechanisms to guide enterprises and the public to actively participate in environment governance, and gradually formed a governance structure with the participation of the governments, enterprises, and the public. This ultimately improves the environment governance in Guizhou Province.

### *3.2. The Evolution of Implementers' Roles*

#### 3.2.1. Analysis of the Role Evolution of Implementers Based on Collaboration Breadth and Intensity

The number of network relationships and connection frequency are used to measure the evolution of implementers' roles. The centrality of network nodes represents the number of implementers connected by an implementer. The higher the centrality, the greater the ability of the implementer to collaborate with other implementers. This is an indicator of collaboration breadth. The connection frequency represents the times that an implementer collaborates with other implementers. The higher the frequency, the more frequently the implementer conducts collaborative activities. This is an indicator of collaboration strength. Based on collaboration breadth and strength, a two-dimensional matrix is constructed, which divides implementers' roles into four types: (1) Low breadth-low intensity (LL) type. Most of the LL-type implementers are edge nodes in the network and play a weak role in information transmission and communication. (2) Low breadth-high intensity (LH) type. The LH-type implementers are the general nodes in the network, which are slightly more persistent in information transmission and communication compared with the LL type. However, the objects of information transmission and communication are limited. (3) The high breadth-low intensity (HL) type. The HL-type implementers are important nodes in the network. The HL-type implementers have a wide coverage, frequent communication, and poor continuity. (4) The high breadth-high intensity (HH) type. The HH-type implementers are core nodes in the network, with wide coverage of information transmission and communication, high frequency of communication, and strong continuity (Figure 3).

In the startup phase (Figure 3a), the number of policies is relatively small, the collaboration between the implementers of most policies is very few, and the network is relatively decentralized and unrepresentative. The MGs and CGs are at the upper right of the matrix, being HH-type implementers. Compared with other implementers, the collaborative governance breadth and strength of MGs and CGs are the greatest; therefore, MGs and CGs are the most active subjects in the phase. Although provincial government and UMCs also have a wide collaboration range, the intensity is not high. Thus, they are HL-type implementers. That is, they play an important role in collaborative governance and collaborate with many implementers, but the continuity of collaboration is poor. Municipal (prefectural) forestry bureaus, municipal (prefectural) agricultural bureaus, and enterprises are LL-type implementers. They are at the edges of the network and have less influence on collaborative governance. It could be seen that in the startup phase, environmental governance in Guizhou Province mainly relies on government supervision, and some implementers are not involved in collaborative governance.




(**a**) (**b**)

(**c**) (**d**)

**Figure 3.** Role changes of the implementers mentioned in the collaborative environment governance policies in Guizhou Province, China since 2005. (**a**) 2005–2009 (**b**) 2010–2015 (**c**) 2016–2019 (**d**) 2020–.

In the strengthening phase (Figure 3b), MGs and CGs remain the core nodes in the network as in the first phase. Therefore, they are HH-type implementers. From the perspective of collaboration breadth, the roles of county (district) ecological civilization bureaus, enterprises, etc., are significantly improved compared with those in the startup phase, and they are HL-type implementers in this phase. In addition, the breadth of information exchange and collaboration increases, but the continuity is still limited. The other implementers are mostly at the network edges, and have no significant impact on the CEG. Therefore, they are LL-type implementers. In conclusion, in this phase, the government departments still play a key role in collaborative governance, the implementers involved in the network are increasingly diverse, and the frequency of collaboration gradually increases. In addition, the participation levels of enterprises and individuals are also improved to some extent.

In the transition phase (Figure 3c), the core role of MGs and CGs are further strengthened, and the UMCs play a prominent core role in the network. Therefore, they are HH-type implementers, far ahead of other implementers in terms of collaboration strength. The collaboration strength is stronger than the collaboration breadth between MGs and other implementers. This indicates that the role of government departments is gradually changing from leading to coordinating. The municipal (prefecture) finance bureaus, county (district) finance bureaus, MBEEs, and county (district) environmental protection bureaus are HL-type implementers. Their collaborative governance is significantly strengthened, showing clear division of labor and enhanced information communication, but the continuity of collaboration strength is still low. Enterprises, schools, and non-governmental organizations are LL-type implementers. This shows their weak roles in collaborative

governance, that is, the multi-party collaborative governance mechanism has not yet been formed.

In the systematization phase (Figure 3d), only MBEEs play an absolutely dominant role in CEG. Therefore, MBEEs are HH-type implementers. Municipal (prefecture) government and county (district) government transform from the HH type to the LL type, and their functions in the CEG gradually decrease. However, provincial government, municipal (prefecture) planning bureaus, and municipal natural resources bureaus play an important role, and enterprises, research institutes, and people's organizations also actively participate in the CEG. Therefore, in this phase, CEG is scientifically planned. Government departments play a service and support role to increase the autonomy and collaboration of other implementers.

To sum up, the CEGN structure has been gradually improved in Guizhou, and the effectiveness of collaborative governance has been continuously enhanced. The core roles of MGs, CGs, UMCs, and MBEEs have gradually stabilized, and the functions of municipal (prefecture) planning bureaus and municipal natural resources bureaus have been constantly improved. In addition, government departments are HH-type implementers in most phases (Figure 3). This indicates that government departments are in the leading position in the CEG, which is a distinctive feature of Guizhou's EGPs. in addition, collaborative governance breadth and intensity for most implementers tend to be 1. This indicates that there are significant differences in collaborative governance between various implementers. Although the collaborative mechanism is extensive, the effect of information exchange and communication is poor. This collaborative environment governance model is different from that in arid regions and economically developed areas [5,10]. Specifically, the reciprocal and symbiotic awareness of the subjects involved in collaborative environment governance in Guizhou Province is stronger, the rights and responsibilities in the governance are clearer, and the order and functions of the subjects are more stable.

#### 3.2.2. Analysis of Function Evolution of Core Implementer Based on the Network Stability

The analysis results of the evolution of implementers' roles and the identification of core implementers show that MGs, CGs, UMCs, and MBEEs are the core nodes in the network in the four phases and play a key role in the CEG. According to the principle of social network analysis [33], the core nodes in the network are eliminated in turn to investigate the change in the network structure indicators and judge the position and function of the nodes. The changes in the network structure indicators after removing MGs, CGs, UMCs, and MBEEs are shown in Table 3.

**Table 3.** Changes in collaborative governance network structure indicators in the four phases after excluding the core implementers in turn.

| | 2005–2009 | | | 2010–2015 | | |
|---|---|---|---|---|---|---|
| **Core Implementer Excluded** | **Number of Network Relationships** | **Connection Frequency** | **Cohesion Index** | **Number of Network Relationships** | **Connection Frequency** | **Cohesion Index** |
| MGs | −42.9% | −58.3% | −29.9% | −17.4% | −50.0% | −8.1% |
| CGs | −42.9% | −58.3% | −29.9% | −17.4% | −50.0% | −8.1% |
| UMCs | −28.6% | −25.0% | −12.6% | −17.4% | −34.6% | −8.1% |
| MBEEs | 0.0% | 0.0% | 0.0% | −4.3% | −0.9% | 6.7% |
| | **2016–2019** | | | **2020–** | | |
| **Core Implementer Excluded** | **Number of Network Relationships** | **Connection Frequency** | **Cohesion Index** | **Number of Network Relationships** | **Connection Frequency** | **Cohesion Index** |
| MGs | −10.3% | −30.0% | −5.1% | −6.4% | −11.7% | −2% |
| CGs | −10.3% | −27.7% | −5.1% | −4.3% | −9.7% | 0.0% |
| UMCs | −14.4% | −28.3% | −9.4% | 0.0% | 0.0% | 0.0% |
| MBEEs | −10.3% | −8.3% | −5.1% | −20.7% | −24.8% | −16.9% |

In the startup phase, the network stability is relatively weak. Depending on the importance, from high to low, the core implementers are MGs, CGs, UMCs, and MBEEs. After removing them one by one, the connection frequency changes the most and that of the MBEEs is 0. This indicates that the four core implementers except MBEEs have strong collaboration strength and support the network stability. The excluding of MGs and CGs all have the greatest impacts on the connection frequency, leading to a decrease of 58.3% and 58.3%, respectively, and the cohesion index also decreases by 29.9% and 29.9%, respectively. This indicates that MGs and CGs play an important organizational role in the network in this phase. After excluding UMCs, the changes of the indicators are relatively small. This indicates that UMCs mainly play a network-stabilizing role. After excluding MBEEs, the three indicators are not changed. This indicates that MBEEs do not play an important role in the network in this phase.

In the strengthening phase, the network stability is enhanced. The order of core implementers in the network according to the importance is consistent with that in the startup phase. Although the excluding of MGs, CGs, and UMCs leads to a decreased impact on the number of network relationships and connection frequency, it has no significant influence on their leading role in the network. However, after excluding MBEEs, the number of network relationships and connection frequency decrease by 4.3% and 0.9%, respectively, but the cohesion index increases by 6.7%. This proves that MBEEs are the edge nodes in the network and play an unimportant role.

In the transition phase, the network stability is further strengthened. The order of core implementers in the network is different from that in the previous two phases. The most important core implementers, in decreasing order, are MGs, UMCs, CGs, and MBEEs. After excluding MGs and CGs, the connection frequency decreases by 30% and 27.7%, respectively, and the cohesion index decreases by 5.1% and 5.1%, respectively. This indicates that the leading role of MGs and CGs in the network stability reduces in this phase. In addition, the excluding of UMCs has the greatest impact on the network. This indicates that UMCs replace MGs and CGs to play a leading role. The excluding of MBEEs has little impact on the network. This indicates that MBEEs play a connecting role in the network.

In the systematization phase, the network stability is enhanced greatly. The most important implementers, in decreasing order, are MBEEs, MGs, CGs, and UMCs. Compared to the previous three phases, the number of network relationships and the connection frequency decrease by 5% and 10%, respectively, after excluding MGs and CGs. The changes are small. In addition, the cohesion index has almost no change. However, after excluding MBEEs, the connection frequency decreases by 24.8%, and the cohesion index increases by 16.9%. These changes are greater than those after excluding MGs, CGs, and UMCs. This indicates that MBEEs play a leading role at this phase. Excluding UMCs has no impact on the indicators. This indicates that UMCs do not play an important role in the CEG. In addition, the excluding of the four core implementers have the smallest impact on the cohesion index in this phase. This indicates that the network cohesion increases, but the connectivity between implementers still depends on the core nodes.

It is found that after excluding the above core nodes, the network structure becomes loose. This indicates that the core implementers are very important to the closeness of the network. With the transformation of the functions of government departments in the collaborative environment governance, the connectivity between implementers and their stability are enhanced. Although the research results summarize some characteristics of the evolution of the network, and comparatively analyze them with the effect of policies, there is no quantitative analysis of the relationship between the collaborative environment governance mode, the characteristics of the collaborative governance structure, and the governance efficiency. This needs to be explored further.

## 4. Conclusions

The regional environment governance faces a great challenge to achieve the goals of carbon peaking and carbon neutrality on time and the green and low-carbon transformation. Promoting collaborative environment governance has become a core issue that urgently needs to be solved in Guizhou Province. Therefore, based on the EGP issued by Guizhou Province since 2005, the social network analysis is conducted to analyze the CEGN characteristics and the node functions' evolution. The following conclusions are drawn:

The analysis results of the network structure show that since 2005, the number of policies related to environment governance and the number of implementers has steadily increased in Guizhou Province. Specifically, the number of policies increases from 21 in the start-up phase to 104 in the transition phase, the number of implementers increases from 11 in the start-up phase to 44 in the systemization phase, the number of network relationships increases from seven in the start-up phase to 140 in the systemization phase, and the connection frequency increases from 24 in the start-up phase to 206 in the systemization phase. However, the cohesion index rises first and then decreases (from 0.436 in the start-up phase to 0.148 in the systemization phase). This indicates that in different phases, although the collaboration between implementers becomes more and more frequent and the network stability and information transmission are improved, the collaboration level is still low. In addition, it can be seen from the network evolution that, with the evolution of the roles of the implementers, the network has gradually changed from a loose pattern to an expanded and balanced system.

It can be seen from the collaboration breadth and intensity analysis results that in the start-up phase, the whole network is in a loose pattern. Only the municipal governments and the county governments belong to HH-type implementers, while other implementers either have insufficient collaborative governance intensity or poor collaborative continuity. Most of the implementers play a marginal role and do not play a substantial role in collaborative governance. In the strengthening phase, the municipal governments and the county governments continue their role in the first stage and are the core nodes, and other implementers still have insufficient collaborative governance intensity or poor collaborative continuity as in the first stage. However, the implementers are becoming diversified and the number of collaborations is gradually increasing. It should be noted that the roles of enterprises and individuals are also reflected to a certain extent in this phase. In the transition phase, the main HH-type implementers include the municipal governments, the county governments, and the urban management committees, but the coordination with the municipal ecological environment bureaus and the county environmental protection bureaus still lacks continuity. Therefore, the multi-party collaborative governance mechanism has not yet been formed. In the systemization phase, only the municipal ecological environment bureaus are HH-type implementers, and the role of the municipal governments and county governments is gradually decreasing. This indicates that the level of collaborative environment governance is enhanced, and the government departments play a service and supporting role.

In this study, the contribution of core nodes to the network stability is studied by excluding the core nodes (municipal governments, county governments, urban management committees, and municipal ecological environment bureaus) in turn. The results show that the role and contribution to the network stability of each core implementer are quite different. For example, the municipal ecological environment bureaus play a supporting role in the network stability in the start-up phase, but become the edge nodes in the strengthening phase. However, the municipal ecological environment bureaus are in a dominant position in the systematization phase. In addition, it is found that excluding the four core implementers in turn has the least impact on the cohesion index. This indicates that the overall relationships in the network have become close, but the communication between implementers (nodes) still depends on the core nodes. It should be noted that the

CEG in Guizhou Province has a series of problems, such as administrative dependence, lack of governance continuity, and low-level enterprise and individual participation.

## 5. Countermeasures and Suggestions

Firstly, the rights, responsibilities, and interests of the implementers should be comprehensively considered in the establishment of a coordination mechanism for collaborative governance, which is vital for ensuring stable and balanced relationships of the implementers. The powers and responsibilities of each implementer should be clarified, to guide them to consciously adjust their roles. That is, the leading role of governments, the participation of non-government subjects, and the mechanism of collaborative governance should be improved. In addition, suitable policies should be selected for each phase to promote collaboration between implementers and enhance the overall governance effect. This is conducive to achieving green and low-carbon transformation in Guizhou.

Secondly, information sharing should be taken as an important path to promote the CEG and strengthen the balanced development of collaborative governance. An information network for CEG can be established to improve the sharing of information and the accuracy and efficiency of policy formulation and implementation. In addition, the collaboration of all implementers should be enhanced and implementers' behaviors should be standardized by checks and balances and self-discipline to achieve a balanced development.

Thirdly, a reward and punishment mechanism should be established to optimize the CEG. The performance appraisal system should be improved, and the green and low-carbon development, rather than overly pursuing GDP growth, should be focused on, to maximize the effectiveness of CEG. In addition, the prominent inaction and following-the-trend phenomenon should be strictly rectified. This helps achieve the goal of coordinated development of Guizhou's economy, environment, and society.

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