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The Intergovernmental Networks of Ecological Protection Policies Issuing Entities in the Source Region of the Yangtze River: A Case Study of Qinghai Province

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ABSTRACT: Ecological conservation and governance play key roles in constructing an ecological civilization society, while intergovernmental cooperation provides new perspectives for cross-regional ecological governance. We employed a social network analysis (SNA) method to examine 110 published ecological policies from 2000 to 2024 in the Source Region of the Yangtze River (SRYR). The study has three key findings. Firstly, intergovernmental collaborative policies on ecological protection showed an upward trend, with intra-provincial collaborations within Qinghai Province being the most frequent. Secondly, four collaboration models were demonstrated, namely: national ministries, national and provincial, cross-provincial and intra–provincial collaborations. National agencies and Qinghai provincial agencies collaboratively set objectives, which Qinghai operationalizes with incentive-constraint measures. Then, the targeted guidelines were launched by national and provincial authorities. Afterward, cross–provincial agreements and mechanisms facilitate joint actions. Thirdly, we revealed the hierarchical structures, including a national network, two central-local sub-networks, three-tier inter-provincial partnerships, and four regional sub-clusters. Core actors include national ministries that coordinate cross-departmental efforts. The Qinghai provincial government serves as a central-local hub. It maintains strong transboundary ties with Aba and Ganzi Prefectures of Sichuan Province. Provincial departments such as ecology and environment, forestry and grasslands, and finance lead intra-provincial collaborations. These findings offer new insights for integrating multi-level governance in ecological protection and ecological civilization construction.

Keywords: Intergovernmental relations; Ecological protection policy; Issuing entities; Social network analysis; The source region of the Yangtze River

1. Introduction

Ecological civilization emphasizes fulfilling harmony between humans and nature, prioritizing ecological conservation and restoration as its cornerstone. As the birthplace of the Yangtze River, the ecological condition of the Source Region of the Yangtze River (SRYR) is not only related to the ecological security of the region itself, but also has an essential impact on the ecological functions of the middle and lower reaches of the region, such as water resource supply, biodiversity protection, and climate regulation capacity [1]. However, driven by climate change and anthropogenic activities, such as mineral extraction, overgrazing, and infrastructure development, the SRYR has faced severe ecological challenges, such as grassland degradation, glacier shrinkage, and permafrost thawing. Such degradation threatens the livelihoods of local herders and disrupts downstream ecological security and social development via altered hydrological cycles [2].

Ecological issues, such as cross-regional water pollution and air pollution, rarely respect administrative borders. When tackled in isolation, single governance units struggle to address these challenges, resulting in a mismatch between

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the integrated nature of ecosystems and fragmented administrative boundaries. Globally, transboundary ecological governance has evolved from fragmented, single-agency efforts to more integrated approaches involving multi-stakeholders' collaboration. Despite this progress, governance effectiveness remains constrained by power structures, interest coordination, and institutional flexibility. Moreover, existing studies have highlighted a range ofapproaches that are used to improve ecological governance. For instance, the U.S.-Canada Great Lakes Agreement combined scientific collaboration with public participation to mitigate eutrophication, though federal-state power dynamics hinder climate adaptation [3]. In Romania, hydropower projects, public litigation, and NGO advocacy frequently drive environmental conflicts [4]. In Southeast Asia, Mekong riparian states have undermined the Mekong River Commission's Prior Consultation for hydropower projects through sovereignty conflicts and restricted participation. At the same time, transnational networks reconfigured engagement scales to challenge power asymmetries [5]. In China, studies have shown that intergovernmental cooperation has proven effective in transboundary ecological governance [6,7]. Scholars emphasize that such cooperation represents a governance model that integrates vertical coordination between national and subnational governments with horizontal collaboration across local jurisdictions [8–10]. Vertically, intergovernmental collaboration is shifting from top–down directive control to performance–based coordination. Horizontally, it has evolved from fragmented "administrative regionalism" to regularized interactions among peer governments, transcending traditional jurisdictional boundaries.

Researchers worldwide have extensively studied intergovernmental relations networks in the context of ecological protection policies in recent years. Chen (2006) [11] proposed a network theory perspective, defining intergovernmental relations as the interconnected networks connecting central and subnational governments. Regarding methodologies, the development of Social Network Analysis (SNA) [12–14], dynamic modeling [15,16], and spatial data analysis [17] has led to a shift in research on intergovernmental cooperation networks from qualitative to quantitative approaches. Previous studies mainly focused on holistic governance, collaborative governance, and network governance theories to analyze the structural characteristics of cross-administrative regional coordination [18]. Moreover, key challenges in China's basin-scale ecological governance have been identified, including mismatches between administrative boundaries and ecosystem regions, delayed horizontal collaboration, low network density, and insufficient stakeholder participation [19,20]. Globally, research on intergovernmental cooperation networks in ecological policy often builds on common-pool resource governance [21] and adaptive governance theories [22], focusing on the dynamic interplay between evolving intergovernmental collaboration and ecological policy performance [23]. Comparative cross-national studies reveal a global shift from hierarchical regulation to collaborative governance in environmental management. The researchers emphasize the importance of aligning of multi-level government preferences and ensuring institutional incentive as key factors that affect policy effectiveness [24,25].

Intergovernmental cooperation in joint policy-making for ecological protection is influenced by multiple factors. On the one hand, conditions like governmental hierarchy differences, regional economic gaps, and geographical distribution, especially the latter, play a significant role in shaping intergovernmental collaboration [26]. Scholars argue that geographically proximate cities are more likely to cooperate, as they share common interests in public affairs such as ecological protection and benefit from frequent interactions that foster trust and long-term partnerships [27–29]. The issues, such as information exchange efficiency, coordination costs, and interest allocation, can hinder the progress of cooperation [30]. However, institutional design, specifically optimizing incentive mechanisms, offers potential to mitigate these challenges. On the other hand, research identified two primary pathways for cross-provincial cooperation: interest-driven and authority-driven approaches, while performance evaluation remains the key driver for intra-provincial collaboration [31].

In China, intergovernmental ecological governance studies mainly focused on economically developed urban clusters, such as the Yangtze River Delta, with less attention paid to ecologically vulnerable regions. Additionally, the interaction models between entities at different governmental levels, including power dynamics, information flow, and policy coherence, remain understudied. Furthermore, it is a critical to explore the characteristics and models of intergovernmental cooperation within the framework of China's Ecological Civilization initiative, which seeks to balance ecological protection with socioeconomic development. To fill up this gap, this study aimed to analyze ecological protection policies jointly issued by multiple administrative entities from 2000 to 2024 inthe Yangtze River source region (SRYR), employing the Social Network Analysis (SNA) method to trace trends in multi-level collaborative policy-making We also visualized network structures of diverse intergovernmental cooperation models, and examined the collaborative characteristics and network configurations among multi-level stakeholders. Our findings will provide empirical insights and practical guidance for optimizing regional ecological governance pathways and policy design.

2. Data and Methodology

This study employed a multi-stage methodology to analyze intergovernmental collaboration models in ecological governance, with a specific focus on Qinghai Province, China (Figure 1)—the water head region of the Yangtze River. Policy documents were systematically retrieved from authoritative sources, including the State Council Policy Database (https://www.gov.cn/zhengce/zhengcewenjianku/, accessed on 25 November 2024), the PKULAW Legal Database (https://www.pkulaw.com/, accessed on 5 December 2024), and relevant official government websites, such as Qinghai provincial government, ecological and environmental departments, forestry and grassland bureaus, water conservancy departments, and agriculture and rural affairs departments (all accessed on 15 December 2024). The search was strictly limited to documents issued between 1 January 2000, and 1 December 2024, and categorized as Regulations, Plans, Notices, Opinions, Measures, or Agreements. Keyword filtering targeted core ecological themes (*i.e.*, "ecological protection", "joint issuance", "ecological compensation", "grasslands", "forests", "wetlands", "national parks") and the geographic focus (*i.e.*, "Qinghai", "Three-River Source", "the Source Region of the Yangtze River"). In addition, some grey documents were also collected during visits to relevant departments in September 2024. After removing duplicate files, the criteria for identifying jointly issued policies were established. To be specific, a jointly issued policy is defined as one that was officially released by more than one institution, or was released by a single entity but involved multiple departments during formulation and implementation. Policies not meeting these joint-issuance criteria were then excluded, resulting in a final dataset of 110 policy documents.

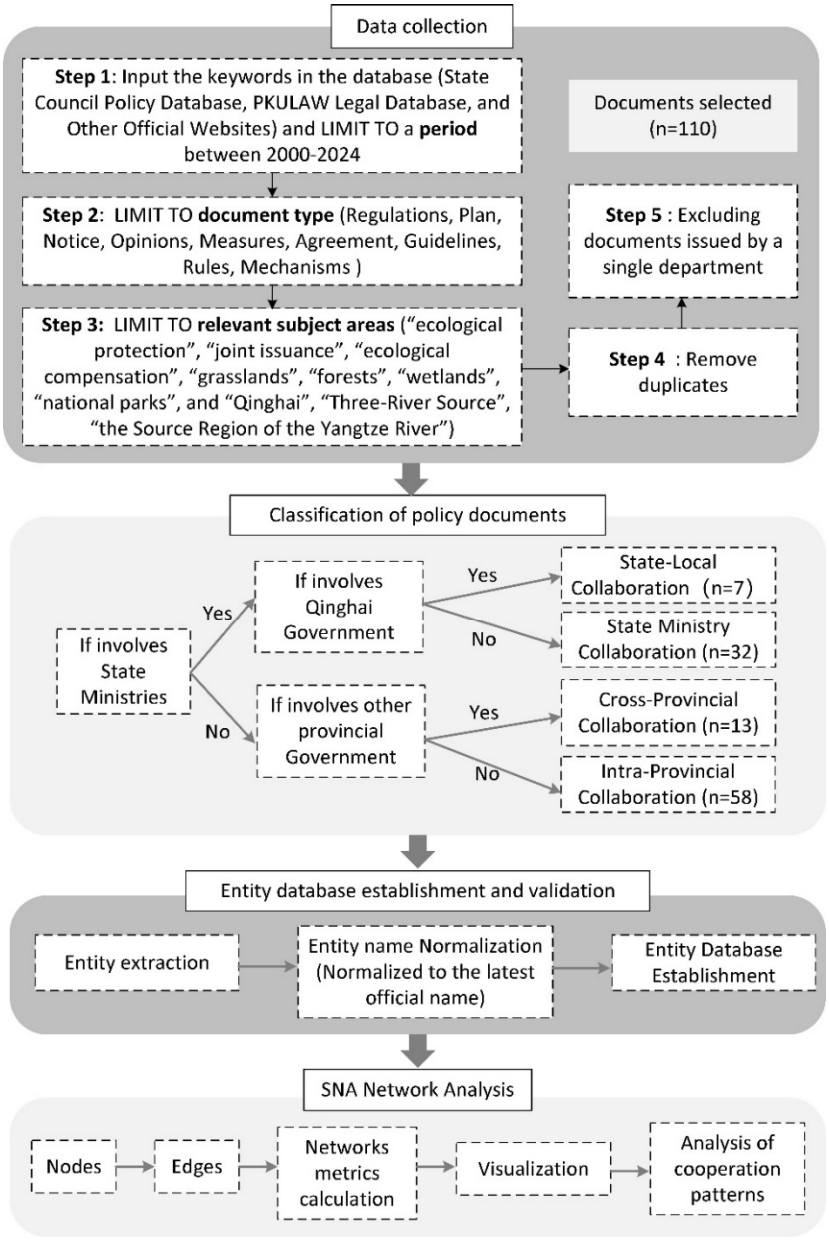

Figure 1. Methodological Workflow for Analyzing Multi-level Intergovernmental Cooperation on Ecological Protection Policy.

Documents were then classified based on the administrative levels of participating governmental entities. The classification process began by identifying whether a document involved central ministries. If so, we further checked for the participation of the Qinghai Government. If not, we then assessed the involvement of other provincial governments, such as Sichuan and Gansu. The collaboration models are divided into four types: State Ministry Collaboration, State-Local Collaboration, Cross-Provincial Collaboration, and Intra-Provincial Collaboration. State Ministry Collaboration refers to a collaborative model in which state ministries work together to issue documents. State-Local Collaboration describes the collaboration between state ministries and provincial authorities in Qinghai. Cross-Provincial Collaboration occurs between the government of Qinghai Province and at least one other provincial government. Intra-Provincial Collaboration covers the collaboration among various departments within the Qinghai provincial administration. We have obtained 32, 7, 13, and 58 policies, respectively, under the four collaboration models mentioned above.

All governmental entities identified as issuing entities in the documents were extracted. Entity names underwent normalization to their latest official full designations to ensure consistency across the dataset. For example, the Ministry of Environmental Protection was renamed the Ministry of Ecology and Environment in 2018, and we united the above two names as the Ministry of Ecology and Environment. Finally, a relational database was established to link documents, normalized entities, and collaboration types.

Using the entity database, collaboration network characteristics were analyzed and visualized with Gephi 0.10.1 software. Quantitative metrics and visualizations were integrated to identify dominant collaboration models and to compare connectivity across the four predefined collaboration types. On this basis, the intergovernmental cooperation network covering both entire-network and individual-node perspectives [32–35] was identified.

Specifically, key SNA metrics were calculated to characterize the network structure, including the number of nodes, edges, network density, average clustering coefficient, and average path length. Nodes represent normalized individual entities. Edges denote relationships between nodes. Edges were established between nodes if they jointly issued at least one policy document, with the total number of edges indicating the frequency of cooperation. Network density measures the tightness of connections among issuing entities, indicating the efficiency of information flow. Ranging from 0 to 1, a value closer to 1 signifies stronger interconnectivity. The formula for network density is as follows.

$$D = \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{x_{ij}}{n(n-1)} \tag{1}$$

where D denotes network density, n is the number of issuing entities in the network, $n(n-1)$ represents the theoretical maximum number of possible collaborations between all entity pairs, and $\sum_{i=1}^{n} \sum_{j=1}^{n} x_{ij}$ is the actual total number of collaborations. If there is a collaborative relationship between entity i and j, the binary variable $x_{ij} = 1$, otherwise $x_{ij} = 0$.

The average clustering coefficient measures the overall tendency of the network to form clusters or "groups", where a higher value indicates tighter relationships, stronger cohesion, and more efficient collaborative exchanges among members. The formula is:

$$CC = \frac{1}{n} \sum_{n} \frac{2d_i}{k(k-1)} \tag{2}$$

where n is the number of issuing entities in the network, k represents the number of neighboring entities connected to entity i, and d_i is the total number of actual collaborative links between entity i and its neighbors.

The average path length represents the mean shortest path distance between any two nodes in the network, reflecting the connectivity of collaborative relationships and measuring the information transmission performance and efficiency of the overall network. For individual-node analysis, we adopt three metrics: degree centrality, closeness centrality, and betweenness centrality [10,36]. This approach focuses on individual nodes to assess their importance and relative positional relationships within the network. Degree centrality quantifies the extent to which an issuing entity engages in outward collaboration and receives incoming collaboration. A higher degree of centrality indicates greater attention and a more central role in the network. The formula for degree centrality is:

$$C_D(i) = \frac{\sum_j x_{ij}}{n-1} (i \neq j) \tag{3}$$

where $C_D(i)$ denotes the degree centrality of node i, $\sum_j x_{ij}$ represents the total number of valid collaborative links between issuing entity i and all other entities j, and n is the total number of issuing entities in the network.

Closeness centrality measures the influence of an issuing entity by taking the reciprocal of the sum of the shortest distances to all other entities in the network. A higher closeness centrality indicates stronger capabilities to acquire and disseminate information. The formula for closeness centrality is:

$$d_i = \frac{1}{N-1}\sum_{j=1}^{N} d_{ij}\,, C_C(i) = \frac{1}{d_i} \tag{4}$$

where d_i represents the mean shortest path length from entity i to every other entity, and the reciprocal of this average distance defines the closeness centrality $C_C(i)$.

The betweenness centrality metric quantifies how often an issuing entity lies on the shortest paths between other entity pairs in the network. A higher betweenness centrality indicates stronger control over information flow or resource exchange within the network. The formula for betweenness centrality is:

$$BC_i = \frac{1}{\frac{(N-1)(N-2)}{2}} \sum_{j\neq k\neq i} \frac{n_{jk}^{i}}{g_{jk}} \tag{5}$$

where BC_i is the betweenness centrality of entity i, N is the total number of issuing entities, n_{jk}^{i} represents the number of shortest paths between entities j and k that pass through entity i, g_{jk} is the total number of shortest paths connecting entities j and k.

3. Results

3.1. Dynamics of Ecological Protection Policy Change

Our study found that the number of jointly issued ecological protection policies in the SRYR exhibited an overall upward trend from 2000 to 2024, which can be divided into three phases based on policy content, objectives, and collaboration intensity. To be specific, the Embryonic Phase (2000–2014) was characterized by a relatively stable but low volume of policy issuance; this period marked the initial stages of stakeholder engagement in collaborative ecological governance. The Slow Growth Phase (2014–2018) was marked by a gradual, fluctuating increase in policy output as joint governance efforts gained momentum, accompanied by modest improvements in cross-entity coordination. The Rapid Development Phase (2018–2024), culminated in a dramatic surge in collaborative policymaking reflecting intensified multi-level and cross-regional cooperation (Figure 2).

The Embryonic Phase (2000–2014) noticed limited policy output, with cooperation primarily between central ministries and Qinghai provincial departments. As national initiatives, the "Grain for Green" pilot of the upper Yangtze in 2000 and the National Ecological Civilization Pilot Zone plan in 2013 laid foundational governance frameworks. Qinghai actively responded to national policies by developing localized mechanisms, such as the 2007 fiscal compensation fund and the 2011 Sanjiangyuan ecological resettlement program. However, cross-sectoral and interprovincial collaboration remained minimal, confined to the Qilian Mountain plan, which involved Gansu, and reflected a fragmented implementation. During this period, 18 policies were launched.

The Slow Growth Phase (2014–2018) brought modest progress, driven by state ministries' designs such as the 2016 Sanjiangyuan National Park pilot and the 2017 Ecological Environment Damage Compensation reform. These initiatives spurred Qinghai to operationalize basin governance through tools such as the Xining River Basin Compensation Scheme, which linked water quality to fund transfers. Yet with only 11 policies issued, collaboration remained centralized, and regional engagement was shallow, focusing on urban pollution, such as the 2018 Haidong air quality plan, without achieving breakthroughs in cross-provincial coordination.

This shifted dramatically in the Rapid Development Phase (2018–2024), marked by an 81-policy surge (73.64% of the total), peaking in 2023, as multi-level cooperation expanded. State ministries led top-down reforms, like the 2018 Yangtze fishing bans. State-local teams devised green economy roadmaps for salt lakes and clean energy. And interprovincial agreements, such as the Qinghai-Tibet-Sichuan river chief system, formalized transboundary coordination. Qinghai innovated locally with "River and Lake Chiefs + Ecological Sheriffs" joint enforcement and territorial restoration plans, while national-provincial partnerships addressed challenges such as noise pollution and desertification through agreements. During this phase, a robust governance system took shape, featuring 7 policies released through state-local collaboration, 20 through state ministry collaboration, 12 through cross-provincial collaboration, and 42 through intra-provincial collaboration.

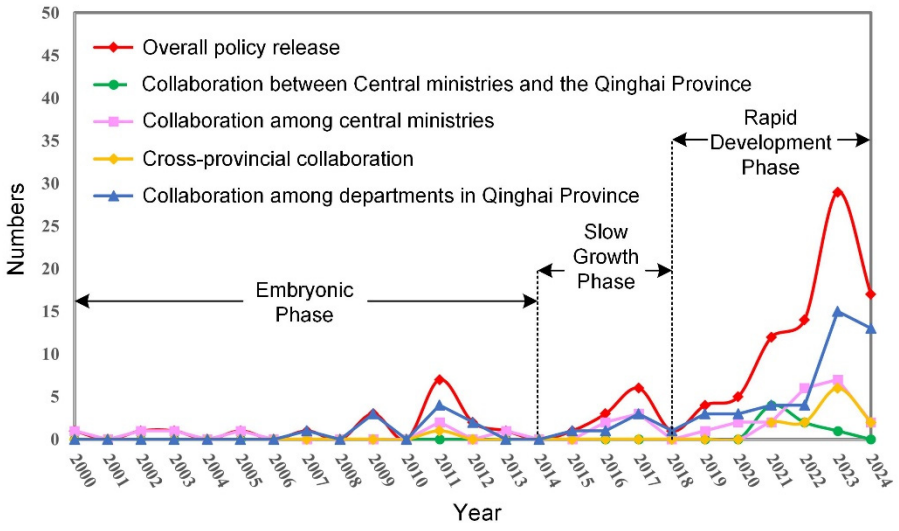

Figure 2. Dynamics of ecological protection policy release in the SRYR from 2000 to 2024.

3.2. Analysis of Intergovernmental Collaboration Networks

In the ecological protection of the SRYR, policy-issuing entities in intergovernmental cooperation include central ministries, basin/national park authorities, provincial governments, and municipal/sub-municipal bodies. Governments at all levels typically follow a process of task definition, policy design, institutional assurance, procedural guidance, and joint action to advance ecological protection [37]. To visualize collaborative relationships, we first constructed node and edge lists, then mapped the four-dimensional intergovernmental cooperation networks for ecological protection policies using Gephi-0.10.1. Node size indicates participation frequency, where larger nodes represent more active entities. Edge thickness reflects collaboration strength, with thicker lines indicating more frequent or intensive interactions. Arrows indicate directional relationships that exist between nodes.

3.2.1. State Ministries Collaboration Network

Between 2000 and 2024, state ministries jointly issued 16 target-oriented policies (e.g., plans and programs), 11 guidance policies (e.g., opinions and guidelines), and 5 implementation-focused policies (e.g., rules and incentive mechanisms). Intergovernmental cooperation networks in this region has become well-developed, forming a multi-sectoral governance structure centered on the National Development and Reform Commission (NDRC) (Figure 3). To address the mismatch between the urgent need for ecological governance and the limited capacity of individual sectors, the NDRC, as the primary vertical regulator, has established a “triangular” partnership with many agencies. Two typical trios are the “NDRC-Ministry of Ecology and Environment (MEE)-Ministry of Water Resources (MWR)” and “NDRC-Ministry of Natural Resources (MNR)-National Forestry and Grassland Administration (NFGA)”, which act as decision-making hubs to coordinate policy co-issuance across sectors. In 2023, the first trio led the issuance of the Key River Basin Water Ecological Protection and Restoration Plan and the Yangtze River Basin Water Ecology Assessment Index Scoring Rules (Pilot). Through their complementary strengths, these agencies effectively advanced integrated policies for basin management and water resource protection.

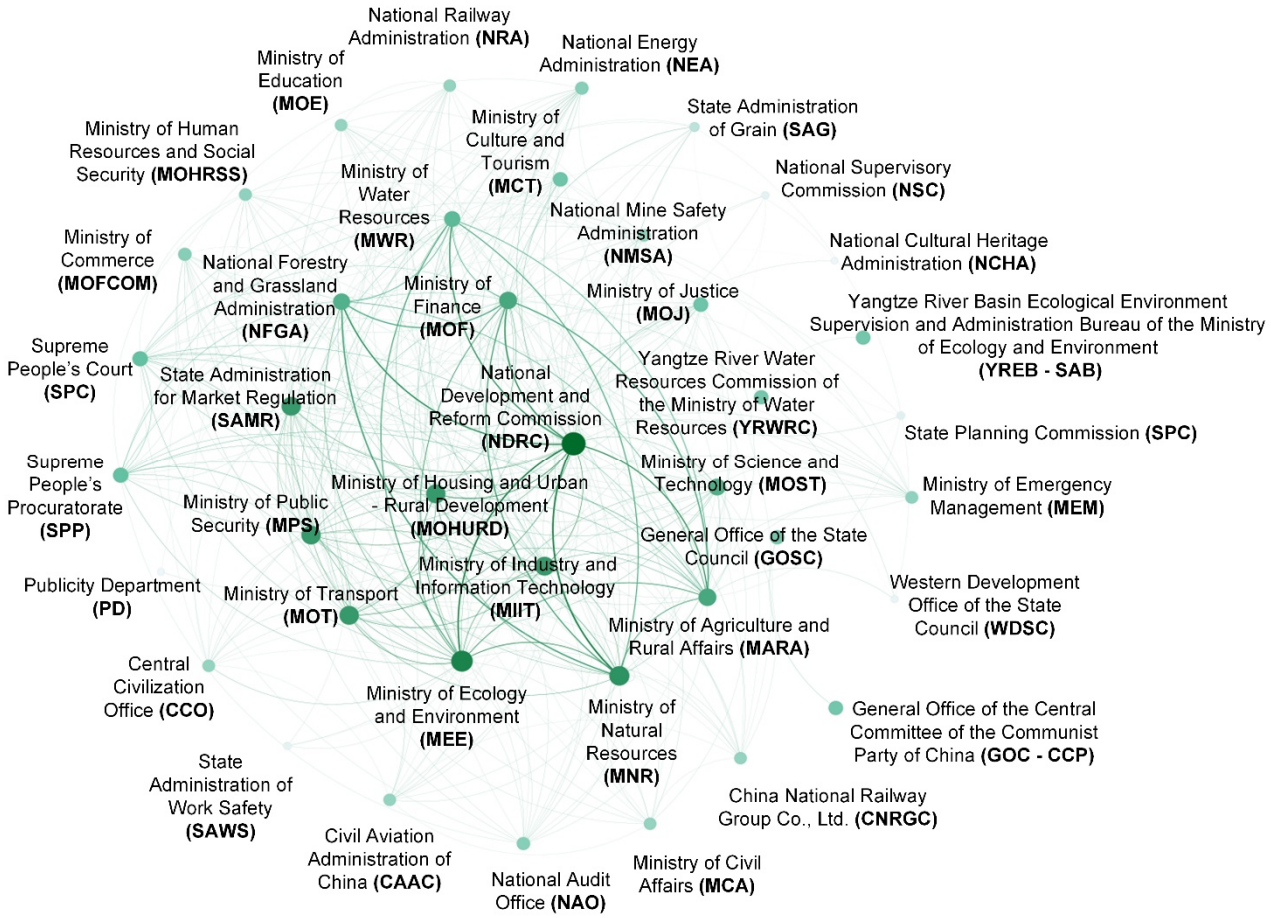

Figure 3. Network of national intersectoral partnerships.

3.2.2. Collaboration Network among State Ministries and the Qinghai Provincial Government

Our analysis revealed that between 2000 and 2024, the state ministries and the Qinghai Provincial Government jointly issued five planning and program policies, along with one agreement. We found that the intergovernmental relations exhibited a coexistence of vertical management and collaborative governance. For example, as a vertically managed authority, the National Forestry and Grassland Administration (NFGA) operationalized national desertification control strategies into quantifiable local mandates through signing target responsibility agreements with Qinghai Province. Qinghai mobilized intra-provincial resources and cross-departmental capacities to drive their implementation (Figure 4a).

On the other hand, most of the jointly issued policies were formulated and issued through joint research and consultation between state departments and the Qinghai Provincial government, rather than stemming solely from top-down directives (Figure 4b). These policies primarily address themes, such as ecological civilization, clean energy, ecotourism, and international cooperation, and are mostly action-oriented programs. Overall, collaboration between state ministries and local governments was primarily driven by administrative mechanisms that combine hierarchical policy transmission with co-designed initiatives. This indicates a clear trend toward transition from vertical management toward collaborative governance.

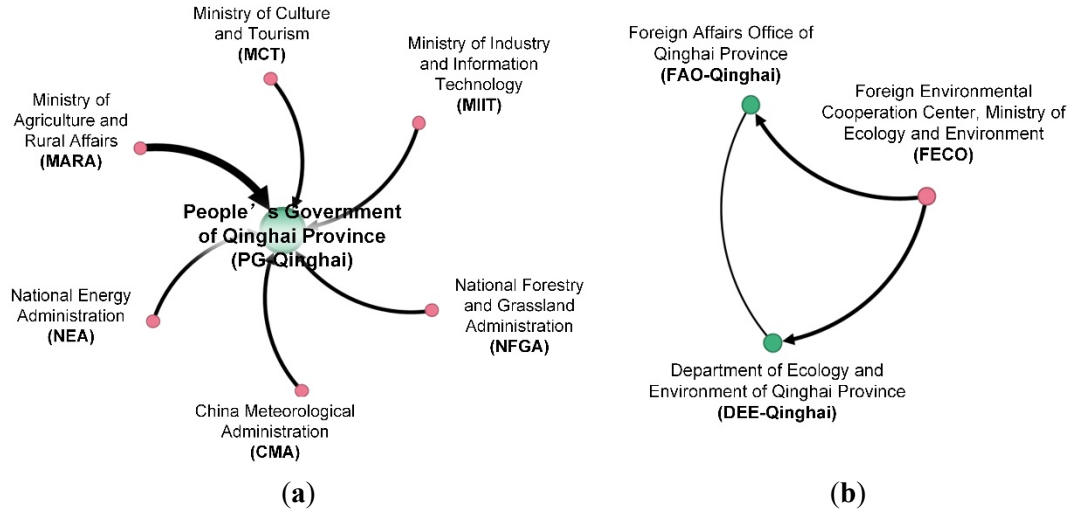

Figure 4. State ministries and the Qinghai provincial government's collaboration network. (**a**) Relationship network of Qinghai People's Government and Relevant Departments; (**b**) Relationship network of Qinghai Departments. Green nodes denote Qinghai provincial departments, and pink nodes represent state ministries.

3.2.3. Cross-Provincial Collaboration Network among Qinghai and Other Provinces

We found 13 jointly issued documents, including eleven agreements, one plan, and one opinion, which form four sub-networks of the cross-provincial collaboration network. At the provincial level (Figure 5a), Qinghai collaborated with Gansu, Xinjiang, and Shandong provinces to address Qilian Mountain ecological governance, desertification control, and technical exchanges, illustrating how top-down policy directives are aligned with regional-specific ecological needs. At the municipal/prefectural-level (Figure 5b,c), Haibei Prefecture collaborated with Inner Mongolia's Alxa League and Gansu's Jiuquan and Zhangye cities to address ecological issues. At the same time, Yushu, Haixi, and Guoluo Prefectures of Qinghao formed intricate networks with counterparts in Sichuan, Tibet, and Gansu provinces, reflecting mid-level administrative coordination on shared ecological challenges. At the county level (Figure 5d), linkages such as those between Qilian County and neighboring counties in Gansu and Inner Mongolia, focused on localized issues, including water protection and enforcement of the "River-Lake Chief" system.

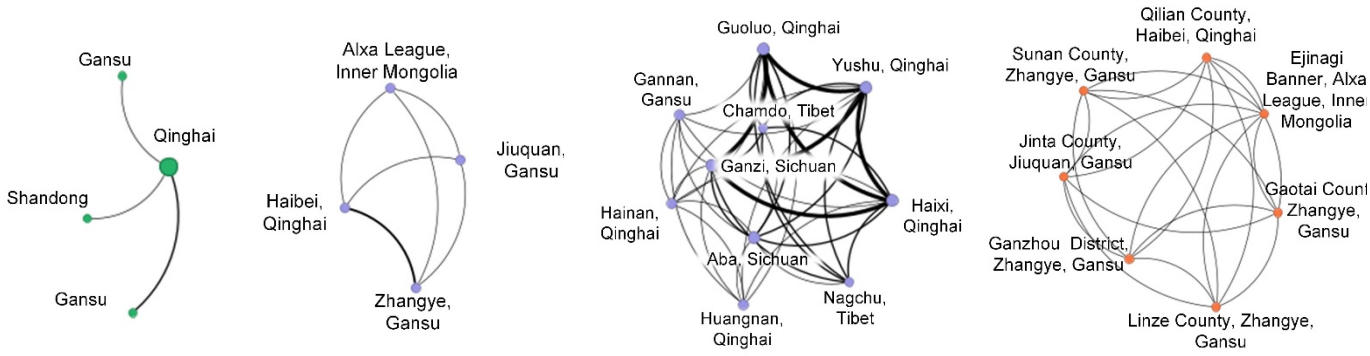

Figure 5. Cross-provincial collaboration network between Qinghai and other provinces. (**a**) Relationship network at the provincial level; (**b**,**c**) Relationship networks at the municipal/prefectural level; (**d**) Relationship network at the county level. Green nodes denote collaborating provinces, purple nodes denote prefectural and municipal-level collaborative entities, and orange nodes denote county-level collaborative entities.

However, the sub-networks exhibited limited interconnection. The cross-provincial cooperation primarily emerges as spontaneous, same-level initiatives rather than integrated cross-hierarchy efforts. Spatially, Qinghai's cross-provincial engagement primarily clusters with adjacent provinces, including Gansu, Xinjiang, Sichuan, and Tibet, except for the outlier partnership with Shandong Province. It aligns with the geographical proximity principle in regional governance, where shared ecological boundaries drive pragmatic, localized cooperation over distant, institutionally complex alliances [25,28]. This structure highlights how administrative scale and spatial adjacency influence the form and function of inter-regional ecological collaboration within China's multi-tier governance system.

3.2.4. Intra-Provincial Department Collaboration Network

We found that the Intra-Provincial departments launched 22 implementation-oriented policies, 13 comprehensive guidance policies, 8 target-oriented plans, and 5 incentive and constraint-related mechanisms. The most complex network emerges within this study, forming four "collaborative clusters" centered on Qinghai Provincial government, and the municipality governments of Xining City, Haibei Prefecture, and Haidong City (Figure 6).

At the provincial level, a crisscrossed cooperation network, led by the Qinghai Department of Ecology and Environment, the Development and Reform Commission, the Department of Finance, the Department of Natural Resources, and the Forestry and Grassland Administration, arises from functional and resource complementarities. These core vertical management entities coordinate through policy formulation, target decomposition, and administrative guidance to steer municipal/county-level implementation.

We also found that Xining City occupies a pivotal position in the intergovernmental collaboration network, featuring both intra-municipal connections and external linkages to the Provincial Meteorological Bureau, Haibei Prefecture, and Haidong City. This indicates Xining's dual role in facilitating both vertical coordination with provincial-level institutions and horizontal collaboration with peer-level prefectures. In Haibei Prefecture's network, joint issuers included government agencies (Water Bureau), judicial bodies (People's Court), special coordination offices (River-Lake Chief System Office), and public security bureau, with policies focusing on addressing key issues, such as river sand mining regulation, integrated river-lake/ecological police enforcement, forest and grassland fire prevention, and joint watershed management. Notably, the Haibei Municipal Public Security Bureau, the People's Court, and the People's Procuratorate occupy central positions within the network. This is because cross-border legal challenges often arise in ecological protection, such as illegal sand mining and deforestation, which require the early intervention of the judiciary to preserve evidence and provide legal guidance that links civil, administrative, and criminal responsibilities in environmental enforcement.

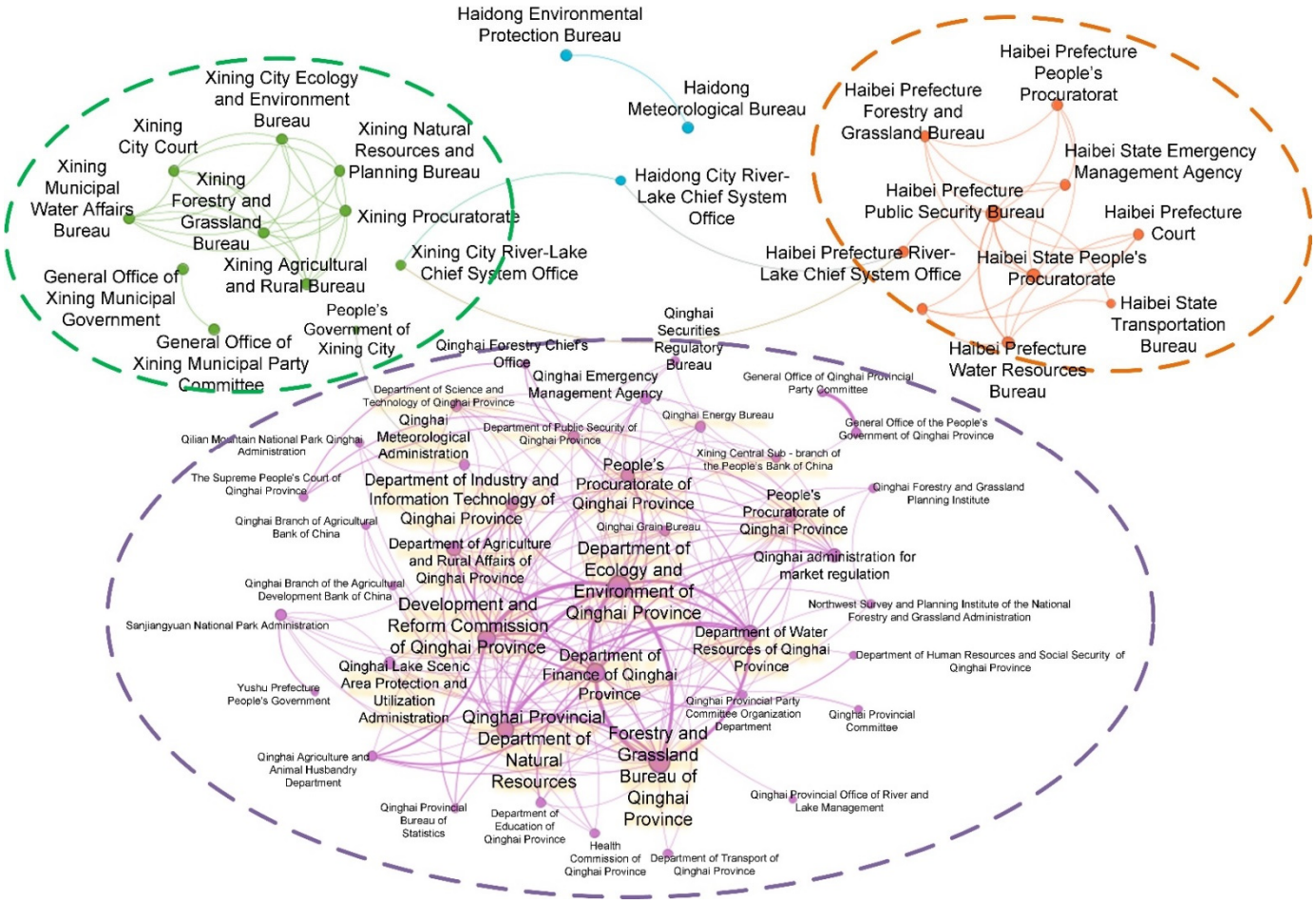

Figure 6. Intra-Provincial Departmental Cooperation Network. Purple nodes denote provincial departments, while green, blue, and orange nodes denote departments of Xining City, Haidong City, and Haibei Tibetan Autonomous Prefecture, respectively.

3.3. Analysis of the Network Structure

3.3.1. Network Structures

We revealed that among the four cooperation models, the State ministries' collaboration network exhibited the highest total number of collaborations (Table 1), alongwith a relatively high average clustering coefficient, which indicated that cross-sectoral cooperation was frequent and well-established in the top-level design of ecological protection policies. In contrast, the state -Qinghai collaboration network showed lower network density, reflecting limited overall collaboration frequency due to hierarchical disparities between state and local entities. In the cross-provincial network, the highest clustering coefficient and shortest path length indicated a solid collaborative foundation shaped by transboundary ecological governance needs in the SRYR, with efficient subgroup formation and rapid information flow across provinces. Meanwhile, the intra-Qinghai provincial network had the lowest density among the four networks (0.1), showing sparse overall interdepartmental linkages. However, its high clustering coefficient and long average path length suggest that localized small-scale collaboration coexists with inefficient information transmission, highlighting the need to improve connectivity within the network.

Table 1. Structural characteristics of the cooperation network among ecological protection policy issuers.

Collaboration Models	Number of Issuing Entities	Total Number of Collaborations	Network Density	Average Clustering Coefficient	Average Path Length
State ministries collaboration network	40	329	0.422	0.868	1.517
State ministries and the Qinghai provincial government collaboration network	10	11	0.2	0.75	1.625
Cross-provincial collaboration network between Qinghai and other provinces	25	69	0.230	0.917	1.115
Intra-Provincial departmental collaboration network	65	207	0.1	0.8	2.181

3.3.2. Network Structure of Issuing Entities

This study investigated the network structure of issuing entities for ecological protection policies using degree centrality, closeness centrality, and betweenness centrality. In the national ministries cooperation network among national departments, the National Development and Reform Commission, the Ministry of Natural Resources, the Ministry of Ecology and Environment, the Ministry of Industry and Information Technology, and the Ministry of Public Security had degree centralities ranking among the top five (Table 2). Their closeness centralities were highly consistent with the degree centralities, indicating that the above-mentioned 5 institutions play a key role in the formulation, release, and implementation of ecological protection policies in the SRYR. Among them, the betweenness centrality of the National Development and Reform Commission far exceeded that of the other four national departments, not only being a core position but also playing a major “bridge” role in connecting other issuing entities.

Table 2. Individual network analysis of ecological protection policy issuers (top 5).

Collaboration Models	Degree		Closeness Centrality		Betweenness Centrality	
	Institution Name	Value	Institution Name	Value	Institution Name	Value
National ministries collaboration network	National Development and Reform Commission	33	General Office of the State Council	1	National Development and Reform Commission	86.13
	Ministry of Natural Resources	33	Yangtze River Basin Ecological Environment Supervision and Administration Bureau of the Ministry of Ecology and Environment	1	Ministry of Ecology and Environment	36.13
	Ministry of Ecology and Environment	31	Yangtze River Water Resources Commission of the Ministry of Water Resources	1	Ministry of Natural Resources	26.29

	Ministry of Industry and Information Technology	31	General Office of the Central Committee of the Communist Party of China	1	Ministry of Agriculture and Rural Affairs	26.29
	Ministry of Public Security	28	National Development and Reform Commission	0.95	State Administration for Market Regulation	22.98
National ministries and the Qinghai provincial government collaboration network	The People's Government of Qinghai Province	6	The People's Government of Qinghai Province	1	The People's Government of Qinghai Province	15
	Department of Ecology and Environment of Qinghai Province	2	Department of Ecology and Environment of Qinghai Province	1	Department of Ecology and Environment of Qinghai Province	0
	Foreign Affairs Office of Qinghai Province	2	Foreign Affairs Office of Qinghai Province	1	Foreign Affairs Office of Qinghai Province	0
	Foreign Cooperation and Exchange Center of the Ministry of Ecology and Environment	2	Foreign Cooperation and Exchange Center of the Ministry of Ecology and Environment	1	Foreign Cooperation and Exchange Center of the Ministry of Ecology and Environment	0
	Ministry of Industry and Information Technology	1	Ministry of Industry and Information Technology	0.55	Ministry of Industry and Information Technology	0
Cross-provincial collaboration network between Qinghai and other provinces	Guoluo Tibetan Autonomous Prefecture of Qinghai Province	9	Guoluo Tibetan Autonomous Prefecture of Qinghai Province	1	Guoluo Tibetan Autonomous Prefecture of Qinghai Province	6
	Haixi Mongolian and Tibetan Autonomous Prefecture of Qinghai Province	9	Haixi Mongolian and Tibetan Autonomous Prefecture of Qinghai Province	1	Haixi Mongolian and Tibetan Autonomous Prefecture of Qinghai Province	6
	Yushu Tibetan Autonomous Prefecture of Qinghai Province	9	Yushu Tibetan Autonomous Prefecture of Qinghai Province	1	Yushu Tibetan Autonomous Prefecture of Qinghai Province	3
	Aba Tibetan and Qiang Autonomous Prefecture of Sichuan Province	8	Aba Tibetan and Qiang Autonomous Prefecture of Sichuan Province	1	Aba Tibetan and Qiang Autonomous Prefecture of Sichuan Province	0.8
	Ganzi Tibetan Autonomous Prefecture of Sichuan Province	8	Ganzi Tibetan Autonomous Prefecture of Sichuan Province	1	Ganzi Tibetan Autonomous Prefecture of Sichuan Province	0.8
Intra-Provincial departmental collaboration network	Department of Ecology and Environment of Qinghai Province	26	Xining City Court	1	Department of Ecology and Environment of Qinghai Province	255.97
	Forestry and Grassland Bureau of Qinghai Province	23	Xining City Procuratorate	1	Forestry and Grassland Bureau of Qinghai Province	161.84
	Department of Finance of Qinghai Province	22	Xining City Forestry and Grassland Bureau	1	Department of Finance of Qinghai Province	127.55
	Development and Reform Commission of Qinghai Province	19	Xining City Bureau of Agriculture and Rural Affairs	1	Department of Transport of Qinghai Province	78
	Department of Natural Resources of Qinghai Province	19	Xining City Bureau of Ecology and Environment	1	People's Procuratorate of Qinghai Province	66.46

We also found that in the cooperation network between national ministries and the Qinghai government, the People's Government of Qinghai Province had the highest degree centrality, closeness centrality, and betweenness centrality, playing a key role in promoting the coordination of various departments' participation in policy release and implementation. In the cross-provincial collaboration network, the Aba Tibetan and Qiang Autonomous Prefecture and Ganzi Tibetan Autonomous Prefecture of Sichuan Province had relatively high degrees of centrality, betweenness

centrality, and closeness centrality. This may be due to geographical proximity, which makes Sichuan and Qinghai have greater cooperation needs and higher possibilities for collaboration in ecological protection. In the intra-province departmental collaboration network, the Department of Ecology and Environment of Qinghai Province had a relatively high degree of centrality and betweenness centrality, both as a leading department in policy release and maintaining close contact with other departments. As the capital city of Qinghai Province, all levels of departments in Xining City occupy a relatively core position in the provincial cooperation network, which is directly related to the administrative hub positioning and resource agglomeration effect of the capital city.

4. Discussion

4.1. About Governance Efficiency

In the state ministries' collaboration network, the cohesive structure (density = 0.422, path length = 1.517) facilitates efficient consensus-building and policy coherence in national ecological governance, minimizing bureaucratic delays in cross-sectoral coordination [38]. However, a relatively high clustering coefficient (0.868) may limit the engagement with specialized stakeholders and the incorporation of diverse perspectives in policy innovation [39].

In the state-local network, despite the low density (0.2), brokerage actors play a key role in bridging structure gaps between national ministries and local ecological departments. For example, Qinghai's Development and Reform Commission (QDRC) secured funding from the central government for 35 grassland restoration projects (2020–2022), demonstrating how strategic brokerage behavior can enable resource mobilization across administrative levels [40].

In the cross-provincial collaboration network, extreme clustering (0.917) and short paths (1.115) enable rapid responses to transboundary issues (e.g., SRYR water governance), validating that shared environmental crises forge efficient subnetworks [41]. However, moderate density (0.230) indicates collaboration remains selective, mainly focused on immediate ecological hotspots rather than systemic integration, which may neglect long-term coordination capacity.

Qinghai's intra-provincial governance network, characterized by an ultra-low density (0.1) and extended path length (2.181), inherently challenges province-wide ecological coordination. Nevertheless, strategic innovations have converted structural constraints into efficiency catalysts because Qinghai Province has prioritized the establishment of core coordination hubs, such as the Qinghai Provincial Ecological Environment Department, to facilitate cross-departmental communication. Furthermore, scientific collaboration has further enhanced governance efficacy through initiatives such as the Yangtze River Ecological Restoration Joint Research Program, which integrated provincial agencies, the Chinese Academy of Sciences, and universities to conduct baseline surveys and develop evidence-based pollution control strategies. Additionally, technological integration via Qinghai's ecological big data platform synthesized hydrological, meteorological, and environmental data from relevant departments, providing reliable data for water quality monitoring. These adaptations validate that sparse networks, while imposing coordination costs, can be engineered into scalable ecological governance testbeds through technological compression, functional prioritization, and institutional hybridity [42].

4.2. Implications for Ecological Protection Governance

Qinghai's multi-tiered governance framework—encompassing state oversight, provincial coordination, and municipal/prefectural implementation—effectively addresses administrative fragmentation by integrating ecological protection outcomes into the officials' performance evaluation system. This institutional mechanism offers a replicable approach to resolving the sovereignty-accountability decoupling observed in global ecological governance [43].

Meanwhile, the integration of national fiscal initiatives, such as the Grain-for-Green subsidy program, with locally tailored supporting policies illustrates how hierarchical funding mechanisms can underpin ecological restoration in fragile environments [44,45]. This provides a potential financial model for transnational ecological cooperation.

Furthermore, Qinghai's institutional innovations, including the establishment of an extensive network of public welfare ecological ranger positions, exemplify the synergistic integration of conservation and development goals. By offering livelihood opportunities to local communities while enhancing ecosystem protection, this model provides valuable insights for reconciling global conservation targets with grassroots livelihood needs [46].

In addition, cross-regional agreements, such as the Qinghai-Xinjiang Desertification Control Alliance and the Qinghai-Tibet-Sichuan River-Lake Chief System Linkage, further exemplify how transboundary environmental challenges can be addressed through joint interprovincial meetings and coordinated law enforcement actions. Their problem-oriented subnetwork construction model presents a collaborative governance paradigm that could be applied to other transnational ecological zones [47].

4.3. Data Limitations and Mitigation Strategies

This study has several limitations. First, our data was mainly obtained from the open-accessed databases, which may overlook unpublished inter-departmental agreements or implementation guidelines, particularly for intra-provincial collaboration. Second, entity normalization requires consistency; however historical institutional restructuring, such as the mergers of ministries, complicates longitudinal role tracking. Third, the exclusion of some single-department documents precludes analysis of how intra-agency priorities may scaffold broader collaborations.

Future research would have to integrate policy content analysis with SNA to evaluate how network structures correlate with ecological outcomes. Additionally, examining the adaptability of Qinghai's governance model across diverse geopolitical and ecological contexts would offer valuable insights into ecological policy network design across China. Such investigations could provide a deep understanding of issues such as enhancing stakeholders' engagement, coordination efficiency among governmental entities at various levels, and policy coherence in ecologically sensitive regions worldwide.

5. Conclusions

Based on social network analysis, this study draws the following conclusions:

First, the trends and characteristics of intergovernmental collaborative policies in ecological protection were identified. From 2000 to 2024, the number of policies jointly issued by inter-governmental cooperation on ecological protection in the SRYR showed an overall upward trend. The most dominant is the issuance of inter-governmental cooperation within Qinghai Province, followed by issuance of national inter-departmental cooperation, then inter-governmental cooperation between Qinghai Province and other provinces, with the least number of joint issuance between national ministries and the Qinghai government.

Furthermore, the logical interplay among the four policy-making tiers was revealed. First, national agencies and Qinghai provincial departments collaborated to define tasks and objectives. Then, provincial agencies translated these into implementation measures that integrated incentives and constraints. To address on-the-ground challenges in ecological protection, national and provincial authorities issued targeted guidelines. Afterward, the governments and departments of Qinghai Province, as well as those of other provinces, issued agreements, programs, and collaborative mechanisms to facilitate joint actions.

Moreover, the structural characteristics of the intergovernmental collaborative network were demonstrated. At the national level, a mature multi-sectoral governance network has emerged through inter-departmental cooperation. National collaborations with Qinghai province comprised two sub-networks. Qinghai's inter-provincial partnerships span three administrative levels, with provinces, cities/prefectures, and counties, respectively. At the provincial-level, four regional sub-clusters were identified, centered around Qinghai Province, Xining City, Haidong City, and Haibei Prefecture, respectively.

Fourth, the leading agencies within each collaborative network were explored. The National Development and Reform Commission, the Ministry of Ecology and Environment, and the Ministry of Natural Resources serve as core national inter-departmental actors. The People's Government of Qinghai Province serves as the core unit for cooperation between the national ministries and Qinghai. Qinghai has the strongest links with Sichuan's Aba and Ganzi Prefectures in inter-provincial cooperation. Within Qinghai Province, the Provincial Department of Ecology and Environment, the Forestry and Grassland Bureau, and the Department of Finance are the primary actors driving intra-provincial collaboration.

Overall, this study demonstrates that Qinghai's collaborative governance framework, with its multi-tiered integration and adaptive coordination mechanisms, provides valuable insights for managing ecological protection in other environmentally fragile regions. These findings not only enrich the theoretical understanding of environmental policy networks but also offer practical references for improving cross-regional coordination, enhancing policy coherence, and designing multi-level governance systems under complex ecological conditions.

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Author Contributions

Conceptualization, X.L. and L.Z.; Methodology, X.L. and L.Z.; Formal Analysis, X.L.; Data Curation, X.L.; Writing—Original Draft Preparation, X.L.; Writing—Review & Editing, X.L., L.Z., Q.S., S.Y.N. and X.W.; Visualization, X.L.; Supervision, L.Z. and Q.S.; Funding Acquisition, L.Z.

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Not applicable.

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Not applicable.

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Data available on request/reasonable request.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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