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Social network analysis of intergovernmental relations and policy tools in China's coastal reclamation management

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As an effective means of sea development and utilization, high-intensity coastal reclamation activities lead to increasingly prominent ecological problems. The accurate implementation of policies is paramount in managing and controlling coastal reclamation. We reviewed China's coastal reclamation management and control policies from 1978 to 2022. Utilizing content analysis and social network analysis, we constructed a policy network to explore the evolution of intergovernmental relations and the habitual combination of policy tools in coastal reclamation management and control. The study shows that (1) The intergovernmental relations of reclamation management and control agencies have evolved from simple to complex, with key departments becoming increasingly prominent; (2) Environmental considerations form the mainstay of policy tools for reclamation control, highlighting an imbalance between supply-side and demand-side approaches; (3) Since 1999, the interactive network between intergovernmental relations and policy tools has begun to exhibit a distinct core-periphery structure, and the social circle has gradually expanded to form a social circle consisting of 23 administrative departments and most departmental policy tools, while there are also some independent working factions at different stages; (4) Policy sustainability is currently inadequate, and in the later stages of management and control, there is a noticeable conflict within the policy texts. The study shows that, China's coastal reclamation management and controlstill faces challenges, It is necessary to continue to explore the policy visualization methods used in coastal reclamation to help balance policy tools and build efficient intergovernmental relations.

KEYWORDS

coastal reclamation, management and control policies, intergovernmental relations, policy tools, social network

1 Introduction

Reclamation, serving as a strategic approach for humanity to acquire land from the sea and expand territorial space, has significantly mitigated the scarcity of land resources (Yin et al., 2022; Ashraf et al., 2019), numerous coastal nations boast a long-standing history of reclamation. The diversity in geographical characteristics across different countries, coupled with the varying demands for land creation, has led to a multitude of reclamation models (Yue et al., 2015; Luo et al., 2022). The Netherlands pioneered large-scale reclamation efforts, primarily driven by the imperatives of survival and safety (Sonneveld et al., 2010). In contrast, the United States and Japan have emphasized reclamation in the context of industrial and urban development (Eom et al., 2012). China, with its 14 coastal provinces and cities, including Taiwan, Hong Kong, and Macau, is endowed with abundant marine resources (Li et al., 2022a). Historically, coastal reclamation in China was predominantly aimed at disaster prevention and mitigation. Since the establishment of the People's Republic of China in 1949, the country has witnessed four major surges in coastal reclamation activities, aligned with varying sea usage demands over different periods. These phases have encompassed a range of activities, including salt drying, agricultural land expansion, tidal flat reclamation, breeding, and industrial development. As environmental carrying capacities continue to reach their saturation points, the conflict between reclamation activities and marine environmental conservation has become increasingly acute. In response, many countries are progressively intensifying their efforts to protect marine ecosystems and are implementing stricter controls on reclamation practices (Colten, 2017; Sanderson, 2001; Zhou et al., 2016). This global shift reflects a growing recognition of the need to balance developmental aspirations with environmental stewardship.

Policy serves as a crucial instrument of social governance, with the government's scientific decision-making forming the cornerstone for the rationalization of governance systems and the modernization of governance capabilities (Drews and VandenBergh, 2016). As an activity that alters the natural attributes of maritime areas, the management and control policies for coastal reclamation should align more closely with the evolving natural environment of sea areas across different periods. As early as 1921, Japan enacted the Public Water Surface Burial Law, establishing approval conditions for coastal reclamation projects. In 1973, Japan passed the Amendment to the Public Water Surface Burial Law, implementing a stringent reclamation approval process to ensure effective management of reclamation activities. In 1990, the Netherlands issued the renowned "Returning Beaches and Returning Water Bodies Plan," proposing restoration recommendations for coastal reclamation aimed at protecting marine ecological functions. Subsequently, South Korea and Japan have introduced relevant marine spatial planning policies to mitigate the adverse impacts of human development activities on the marine ecological environment, reflecting a growing global emphasis on marine environmental protection.

Most of China's coastal reclamation policies have been focused post-1980s, centering primarily on environmental governance (Jiang et al., 2021). The 1990s saw a surge in the demand for sea area development, leading to various challenges, including the irrational development and utilization of sea areas (Tian et al., 2016). Subsequently, the policies governing reclamation management and control have been progressively refined, with an increasing emphasis on stringent control measures (Cai et al., 2012; Ouyang et al., 2021; Wang and Tian, 2016). Notably, in 2018, the State Council's Notice on Strengthening the Protection of Coastal Wetlands and Strictly Controlling Coastal Reclamation unequivocally stated that, barring major national projects, all forms of reclamation are to be prohibited.

Policy tools are the instruments utilized by policymakers to achieve specific policy goals (Capano and Howlett, 2020). These encompass a range of methods and measures, including but not limited to legal regulations, economic incentives, and administrative directives. The selection and application of these tools necessitate a careful consideration of various factors, such as the policy's objectives, background, and target audience. Different government departments or policy scenarios might deploy diverse combinations of these tools to optimize policy outcomes. This paper aims to investigate the scientific and rational selection and application of policy tools within the framework of China's coastal reclamation policies. However, the variance in government involvement and the role of policies result in differing definitions and classifications of policy tools (Howlett, 2009). Establishing a clear classification standard and definition for policy tools in the realm of reclamation management and control is a primary objective of this study.

The concept of intergovernmental relationships encompasses the intricate dynamics between various government entities (Beck and Mahony, 2018). This term broadly refers to both the horizontal relationships among government departments operating at the same hierarchical level and the vertical relationships between departments at different levels (Schenider and Ingram, 1993). The effective and standardized functioning of these intergovernmental relations plays a pivotal role in fostering development across diverse societal sectors. The formulation and implementation of policies, serving as the primary mechanism in this context, are fundamental in enhancing the standardization and efficiency of intergovernmental interactions (Baranzini et al., 2017). In the specific case of coastal reclamation management and control, the process involves a complex network of multiple stakeholders. The execution of management and control measures is significantly influenced by the nature of intergovernmental relationships. This is particularly evident in the context of the horizontal relationships among central government departments, which play a critical role in shaping the policies governing coastal reclamation (Deng and Zuo, 2021). Understanding and navigating these relationships is crucial for effective policy implementation, ensuring that the diverse and often competing interests of various stakeholders are adequately balanced and addressed.

In the context of stringent reclamation management and control, the sustainability of these policies encounters significant challenges. Prior research in this domain has predominantly

concentrated on the evolution of reclamation policies (Gong, 2021), their evaluation and optimization (Bi et al., 2012), and the effective utilization of existing reclamation resources (Mu, 2014; Wang, 2016). However, these studies have largely been grounded in spatial qualitative analyses, but there are fewer policy text tools that reveal the reclamation activities, and there remains a dearth of comprehensive information for a detailed analysis of the specific processes and dynamics involved in policy implementation. The efficacy of collaboration among government agencies and the judicious application of policy tools are crucial in the realm of reclamation management and control. Government departments, as the primary executors of policies, leverage a variety of policy tools to achieve set objectives (Capano and Howlett, 2020). In doing so, they engage in collaborative efforts, forming a complex social network characterized by intergovernmental relationships and the strategic use of policy instruments. The nature of these relationships is a critical component of policy networks (Perkins et al., 2015). This study aims to delve into the evolution of intergovernmental relations and assess the roles and influence of various government departments in coastal reclamation management and control. To achieve this, we will analyze specific network parameters, including the centrality of government departments and policy tools, the core-periphery structure, and the dynamics of cohesive subgroups over time.

In this study, we employ both content analysis and social network analysis methodologies. Content analysis is utilized for the initial statistical quantification, providing a comprehensive depiction of reclamation management and control policies spanning from 1978 to 2022. Social network analysis, on the other hand, is applied to construct a sophisticated interactive network. Our study primarily aims to: (1) thoroughly investigate the intergovernmental network suggested by reclamation management and control policies, seeking to reveal its evolutionary patterns; (2) elucidate the diversity, application, and progress of policy instruments employed in reclamation management and control during different periods from 1978 to 2022, thereby understanding potential gaps and overlaps in the recently used policy tools; (3) comprehend the consolidation of policy instruments used by various government departments, and track the formation and evolution of different factions within the field of reclamation control. Our study aspires to contribute a nuanced understanding of policy dynamics in the context of coastal reclamation, highlighting the intricate interplay between policy tools and intergovernmental relations.

2 Materials and methods

2.1 Datasets and preprocessing

As early as 1979, the concept of "reclamation protection" began to emerge in various documents, including those concerning the protection of aquatic resources. However, during this initial phase, the focus was predominantly on the development aspect of reclamation, with relatively lax control measures in place. It wasn't until 1982 that China officially commenced its reclamation management and control initiatives. In our research, we employed "reclamation" and "tidal flat reclamation" as primary search terms. We systematically gathered data on reclamation management and control policies using Peking University's comprehensive database (https://pkulaw.com/law) and State Council Policy Document Library(https://sousuo.www.gov.cn/zcwjk/policyRetrieval). Given the extensive volume of policy texts pertaining to coastal reclamation management and control, we implemented stringent criteria to ensure the precision and relevance of our policy selection. These criteria included: (1) the policy must be issued by the highest state authority, namely the State Council or its departments; (2) the policy text should be directly related to reclamation control and take the form of laws, regulations, measures, plans, or notices, explicitly excluding industry standard documents. Following these guidelines, we ultimately compiled 226 pertinent documents. For a more nuanced analysis, we categorized the evolution of reclamation management and control policies into five distinct stages (Figure 1). This chronological division allows for a comprehensive understanding of the policy shifts and developments over time, reflecting the changing priorities and approaches in the realm of coastal reclamation management.

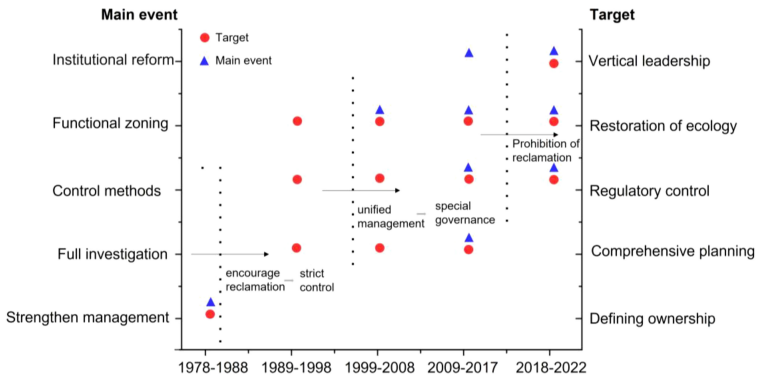

FIGURE 1
Each stage of coastal reclamation management and control policies.

2.2 Policy text encoding and statistics

2.2.1 The selection of the types of policy tools

The development intensity of coastal reclamation and the sea usage patterns in each period have given rise to distinct models of reclamation management and control (Smyth and Dearden, 1998). These models are integral to the management and control of ecological environmental space, playing a pivotal role in advancing the construction of ecological civilization (Wang et al., 2021). The concept of supply-side reform is intricately linked to the building of ecological civilization. Its synergistic relationship with the demand side is instrumental in fostering the continuous enhancement of the ecological civilization system. This synergy provides a robust theoretical and practical foundation for the formulation of reclamation management and control policies in the new era. In our analysis of China's coastal reclamation management and control policies, we have adopted the theoretical framework of policy tools as proposed by Rothwell and Zegveld (Rothwell and Zegveld, 1984). We categorized the policy tools into three distinct groups: supply side (Figure 2A), demand side (Figure 2B), and environment side (Figure 2C). This classification is based on a thorough examination of the specific content and practical applications of these policies. To circumvent issues such as inconsistent categorization, overlap, and semantic ambiguity among different policy tools, we have meticulously defined each tool in relation to its policy context. Furthermore, we have systematically coded the content of these policy tools in accordance with established coding principles, ensuring a scientific and precise analysis. This methodical approach enables a clearer understanding of the policy tools' roles and functions within the broader context of coastal reclamation management and control.

2.2.2 Encoding process and results

In our study, policy coding is meticulously structured in a hierarchical format, starting from the publishing unit and cascading down to the first-level title and subsequent paragraphs (Table 1). This coding process adheres to stringent standards to ensure accuracy and clarity: (1) Coding Unit Standards: Each government department, as a coding unit, is restricted to containing no more than two identical policy tools to maintain distinctiveness in policy categorization. (2) Comprehensive Content Inclusion: Each coding unit is required to encapsulate all relevant content within its scope, ensuring a thorough representation of the policy's intent and scope. (3) Avoidance of Semantic Overlap: In instances where the same text content could potentially represent two or more policy tools, a filtering process is employed to eliminate such content. This step is crucial to prevent semantic confusion and overlap among different policy tools. To mitigate the risk of subjective bias in coding, we have conducted a reliability test for the coding process. The coding consistency coefficient, ranging between 0.8 and 0.9, indicates a high level of credibility in the coding results (Hu et al., 2019). This coefficient confirms that the policy coding undertaken in this research aligns well within the consistency interval, thereby validating the results.

Furthermore, it is important to note that all policies referenced in this article are sourced from official government websites or authorized legal resource sharing platforms (such as Peking University magic weapon). This sourcing approach further substantiates the validity of the policies used in our analysis, ensuring that our research is grounded in officially recognized and authoritative information.

The analysis of the evolution in intergovernmental relations from 1978 to 2022 necessitates an understanding of the changing landscape of government departments, as these entities have

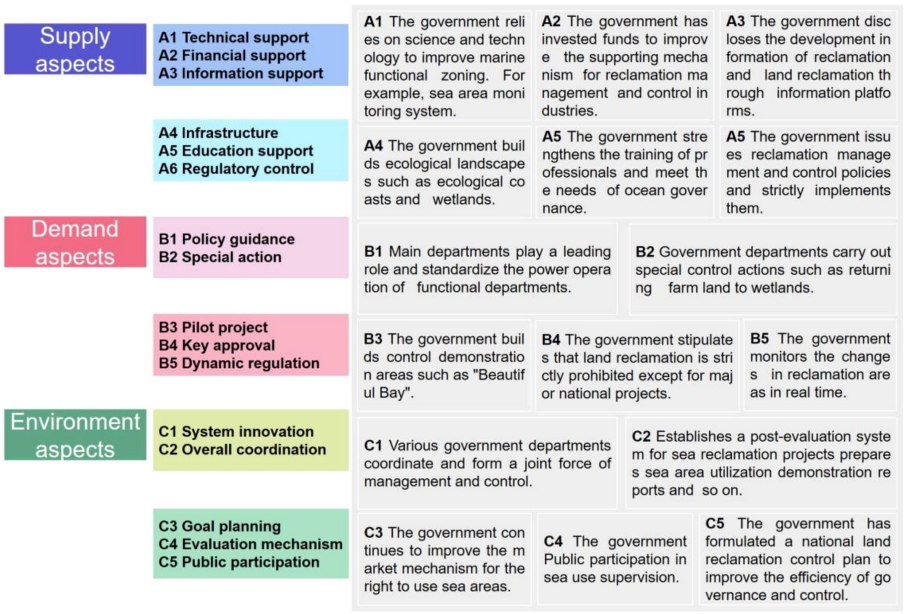

FIGURE 2
Types and explanations of policy tools. **(A)** supply side; **(B)** demand side; and **(C)** environment side.

TABLE 1 Coding procedures and examples.

Policy tool & Government department	Details	Coding
RC, PDP	Construct an institutional system of ecological civilization coordinate the development of land and sea protection … precise strategic positioning and build a demonstration area and test area for an ecological civilization system.	4-1-1-1
MNR, MEE, SFGA, TD	Deal with the historical problems of port reclamation actively and steadily.	13-4-1

RC, regulatory control; PDP, Pilot Demonstration Project; MNR, Ministry of Natural Resources; MEE, Ministry of Ecology and Environment; SFGA, State Forestry and Grassland Administration; TD, Transportation Department.

undergone various updates and restructurings over time (Table 2). During this period, an increasing number of government departments became involved in reclamation control actions (Figure 3A). Concurrently, there was a continuous enhancement and diversification of policy tools (Figure 3B), with a predominant focus on environmental aspects (Table 3).

In the initial phase from 1978 to 1998, the then State Land Bureau and the State Oceanic Administration jointly issued a pivotal Notice on Strengthening the Management of Tidal Flat Resources. This marked the first significant step towards emphasizing the government's role in controlling the property rights of beaches and tidal flat resources.

TABLE 2 Evolution of government departments from 1978 to 2022.

Time	Foundation	Change rules
March 10, 1998	Document of State Council [1998] No. 5	The Ministry of Geology and Mineral Resources, the State Land Administration, the State Oceanic Administration, and the State Bureau of Surveying and Mapping jointly formed the Ministry of Land and Resources.
March 15, 2008	Document of State Council [2008] No. 73	The State Environmental Protection Administration would no longer be retained, and the Ministry of Environmental Protection would be established.
March 13, 2018	Document of State Council [2018] No. 6	The Ministry of Land and Resources, the State Oceanic Administration, and the National Bureau of Surveying, Mapping and Geoinformation jointly established the Ministry of Natural Resources and retained the brand of the State Oceanic Administration.
		The Ministry of Supervision was no longer retained and merged into the National Supervisory Commission.
		Formation of the National Forestry and Grassland Administration, which was administered by the Ministry of Natural Resources.
		The Ministry of Agriculture would no longer be retained, and the Ministry of Agriculture and Rural Affairs would be established.
		The Ministry of Environmental Protection would no longer be retained, and the Ministry of Ecology and Environment would be established.

The period from 1999 to 2008 saw the former Ministry of Land and Resources and the Bureau of Oceanography maintaining a dominant role. During this time, various government departments actively engaged in reclamation management and control, with a noticeable increase in the overall coordination of policy tools. From 2009 to 2017, entities such as the Environmental Protection Committee and the former Ministry of Environmental Protection began to play an influential role in regulation. This era was characterized by the gradual formation of an ecological protection paradigm for reclamation wetlands, where dynamic monitoring and ecological environment quality assessments emerged as primary control tasks.

In the most recent phase, from 2018 to 2022, the Ministry of Natural Resources and the Ministry of Ecology and Environment have become increasingly prominent, appearing 69 and 71 times respectively in relevant documents. They have emerged as the core departments in reclamation management and control. Conversely, departments like the National Energy Administration, the Cultural Relics Administration, and the Railway Administration have had minimal involvement, indicating their peripheral role in reclamation management and control.

2.2.3 Social network analysis

To comprehensively analyze the interplay between intergovernmental relations and policy tools across different stages, we undertook a detailed secondary statistical analysis of the coding data. This process enabled us to construct a two-mode matrix, effectively capturing the dynamics between intergovernmental relations and policy tools as outlined in Equation 1.

The 2-mode network, akin to the 1-mode network, necessitates identifying a configuration that closely approximates the ideal image. This involves locating high-density and low-density blocks along the main diagonal, albeit with distinct implications for each network type. In a 2-mode network, the core is constituted by a set of segmented actors who are intricately linked with specific events. Concurrently, the event partitions are intimately associated with the actors in the core segments, forming a "core" that is essentially a cluster of co-occurring actors and events. Conversely, an edge comprises a series of segmented events or actors, where actors do not co-occur in events and do not share actors between events.

A social network is fundamentally a construct of social actors and the intricate web of relationships that bind them. Social network analysis, therefore, is a method uniquely suited to examining relational data,

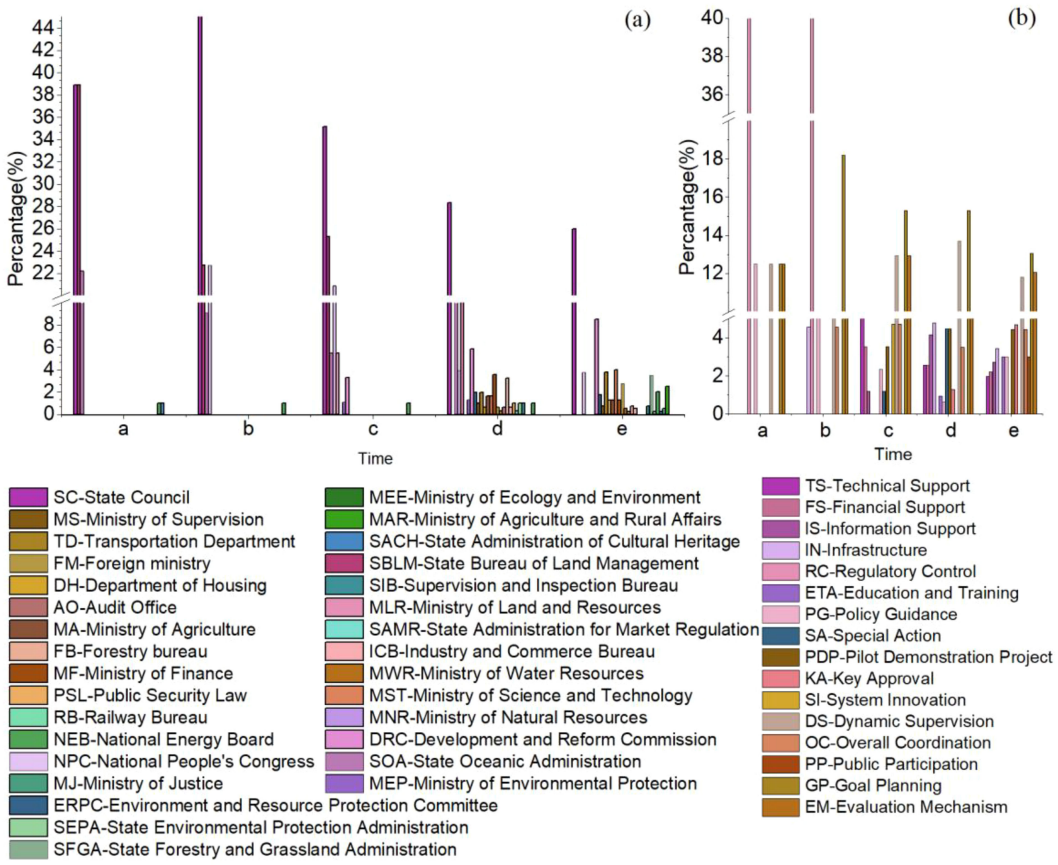

FIGURE 3
Statistics of government departments **(A)** and policy tools **(B)**.

which is distinct from the study of independent entities or intergroup dynamics. This analytical approach is particularly effective in exploring the nuances of intergovernmental relations and policy tools.

Utilizing social network analysis, we focused on assessing the centrality within the network of intergovernmental relations and policy tools. This assessment was crucial in identifying the core and peripheral structures within these networks. To achieve this, we employed block models and image matrices, which are sophisticated tools in network analysis. These methods allowed us to delineate and understand the complex patterns of interaction and influence within the network, providing valuable insights into the structural and functional aspects of intergovernmental relations and policy tools in the context of policy implementation and governance.

TABLE 3 Frequency of use of policy tools from 1978-2022.

Time	Supply aspects	Demand aspects	Environment aspects
1978-1988	8	2	7
1989-1998	11	2	9
1999-2008	37	41	43
2009-2017	123	22	132
2018-2022	144	88	170
Total	323	155	361

$$\begin{bmatrix} 1\ 0\ 3\ 2\ 0\ 0 \\ \cdots \quad (a) \\ 0\ 1\ 2\ 0\ 1\ 1 \\ 1\ 0\ 5\ 3\ 0\ 1\ 0 \\ \cdots \quad (b) \\ 0\ 1\ 2\ 0\ 1\ 0\ 1 \\ 1\ 1\ 0\ 0\ 13\ 6\ 0\ 3\ 1\ 3\ 1\ 3\ 0 \\ \cdots \quad (c) \\ 0\ 0\ 0\ 0\ 0\ 1\ 0\ 1\ 0\ 0\ 1\ 0\ 0 \\ 3\ 28\ 20\ 0\ 8\ 9\ 3\ 4\ 0\ 0\ 2\ 8\ 0\ 2 \\ \cdots \quad (d) \\ 0\ 3\ 1\ 0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0 \\ 3\ 30\ 22\ 0\ 10\ 13\ 3\ 8\ 1\ 1\ 2\ 8\ 1\ 2\ 0 \\ \cdots \quad (e) \\ 0\ 4\ 1\ 0\ 1\ 0\ 0\ 1\ 0\ 0\ 0\ 0\ 0\ 0\ 0 \end{bmatrix} \quad (1)$$

Note: a-e refers to 1978-1988, 1989-1998, 1999-2008, 2009-2017, 2018-2022, rows represent the number of different policy tools used by the same government department,the columns

represent the frequency with which different government departments have adopted the same policy instrument.

3 Results

3.1 The centrality evolution of coastal reclamation policy network

In our research, we meticulously measured the centrality indicators of intergovernmental relations and policy tools, aiming to analyze their respective positions within the policy network across various time periods. Recent studies have provided clear definitions for degree centrality, closeness centrality, and betweenness centrality in the dual-mode network formed by intergovernmental relations and policy tools within the context of marine environmental governance (Li et al., 2022b).

These centrality measures are instrumental in understanding the influence and connectivity of various entities within the network. Degree centrality focuses on the number of direct connections an actor has within the network, indicating their immediate influence. Closeness centrality reflects the degree to which an actor is near all other actors in the network, highlighting their accessibility and potential for rapid dissemination of information. Betweenness centrality, on the other hand, measures the extent to which an actor lies on the shortest path between other actors, signifying their role as a bridge or broker within the network.

By applying these centrality measures, our analysis sheds light on the evolving roles and significance of different government departments and policy tools within the broader context of policy implementation and governance. This approach allows for a nuanced understanding of the dynamic interplay and changing influence patterns among the actors involved in the policy network over time.

3.1.1 Centrality of government departments

In the context of policy tool utilization, when specific users of a policy tool do not engage with other policy tools, this exclusivity results in an increased betweenness centrality for that particular policy tool. Similarly, when a government department employs a specific policy tool that is not utilized by other departments, the betweenness centrality of that government department correspondingly increases. Notably, the betweenness centrality across intergovernmental relations and policy tools is observed to be the lowest among the three centrality indicators (Tables 4, 5).

This pattern indicates a prevalent trend where a single government department often employs multiple policy tools, and conversely, multiple government departments frequently utilize the same policy tool. Such a scenario underscores the complexity of the reclamation policy network. Conducting a systematic analysis of this network holds significant theoretical and practical implications. It allows for a deeper understanding of the intricate interplay between various government entities and the diverse range of policy tools at their disposal. This understanding is crucial for effectively navigating and managing the multifaceted dynamics of policy implementation and governance within the realm of reclamation.

The intergovernmental relationship dynamics in reclamation management and control have undergone a significant transformation, evolving from a simplistic framework to a more complex structure over the years, as depicted in Figure 4. From 1978 to 2022, the attention and involvement of relevant government departments in reclamation management and control have progressively intensified.

In the initial phase from 1978 to 1998, the reclamation management and control policies were relatively few, resulting in the centrality of government departments not being particularly pronounced during this period (Figures 4A, B). However, from 1999 to 2008, the centrality indicators for the former Ministry of Land and Resources and the State Oceanic Administration were notably higher, positioning them at the core of the policy network established during this time (Figure 4C). The National Development and Reform Commission, along with the former Ministry of Environmental Protection and the Environment and Resources Commission, began their involvement in the reclamation management and control network. Although their positions were peripheral, their participation indicated an increasing consideration for the protection of the marine ecological environment.

The period from 2009 to 2017 marked a significant increase in complexity within the policy network, with as many as 23 intergovernmental relationship nodes between government departments (Figure 4D). In 2009, the State Oceanic Administration responded to the National Audit Office's directive to strengthen the audit of environmental resources in coastal zones, particularly focusing on the ecological damage caused by tidal flat reclamation. Subsequently, the State Council issued responses to the marine functional zoning of each coastal province, aiming to comprehensively control the extensive use of reclaimed land and related issues.

From 2018 to 2022, in line with the reform of the ecological civilization system, the management and control of reclamation became more centralized and unified, leading to a stabilization in the network structure (Figure 4E). The establishment of the Ministry of Ecology and Environment, in conjunction with the Ministry of Natural Resources, marked their evolution into the core departments within the policy network. The interconnections among various institutions strengthened, fostering policy synergy in the enhancement of marine ecological civilization construction. This period reflects a concerted effort towards a more integrated and cohesive approach in managing and controlling reclamation activities, aligning with broader environmental and ecological objectives.

3.1.2 Centrality of the control policy tools

The policy tools employed in the management and control of coastal reclamation predominantly focus on environmental aspects, with legal regulations, dynamic monitoring, and evaluation mechanisms playing a pivotal role throughout the process. These tools have seen a continual increase in their centrality over time.

TABLE 4 Measurement results of centrality of government departments.

Time	Government departments	Degree	Closeness	Between
1978-1988	State Council	0.500	0.625	0.500
	State Bureau of Land Management	0.667	0.714	0.288
	State Oceanic Administration	0.667	0.714	0.288
1989-1998	State Council	0.571	0.684	0.476
	National People's Congress	0.286	0.565	0.071
	State Oceanic Administration	0.571	0.684	0.250
	Ministry of Land and Resources	0.571	0.684	0.250
	…			
1999-2008	Ministry of Land and Resources	0.692	0.771	0.228
	Ministry of Environmental Protection	0.231	0.551	0.013
	State Oceanic Administration	0.846	0.871	0.329
	Environment and Resource Protection Committee	0.231	0.551	0.013
	…			
2009-2017	Ministry of Environmental Protection	0.533	0.787	0.043
	State Oceanic Administration	0.467	0.747	0.033
	Ministry of Land and Resources	0.333	0.678	0.011
	…			
2018-2022	Ministry of Natural Resources	0.824	0.940	0.128
	Development and Reform Commission	0.706	0.887	0.070
	Ministry of Ecology and Environment	0.824	0.940	0.105
	State Forestry and Grassland Administration	0.529	0.818	0.036
	…			

…, Due to the excessive length of the data series, we sorted by numerical values and selected parts for display. This behavior had no influence on the analysis of results.

In the initial phase from 1978 to 1988, there was a notable absence of clear directives or dedicated regulations for reclamation management and control, rendering the policy tools of that era relatively ineffective. However, from 1989 to 1998, there was a marked increase in the centrality of target planning policy tools. This shift can be attributed to the State Council's initial proposals on local rivers, lakes, and watershed management, coupled with the issuance of a notice on national ecological environment construction in 1998. This notice advocated for the orderly reversion of excessively reclaimed farmland, thereby fostering a more planned approach to reclamation management and control.

The period from 1999 to 2008 witnessed a heightened focus on the interplay between supply and demand in reclamation management and control. Policy measures such as special fund support, ecological protection pilot projects, and comprehensive planning and coordination began to be increasingly utilized by various government departments, leading to significant advancements in reclamation management and control actions.

From 2009 to 2017, with the collaborative issuance of the Reclamation Management and Control Measures, there was a continuous enhancement of the reclamation management and control system. By 2022, policies related to coastal reclamation predominantly concentrated on restoring damage to the marine ecological environment and addressing numerous historical issues stemming from coastal reclamation. The scope of oversight over reclamation activities expanded to include public participation, leading to a continuous improvement in the centrality of public participation policy tools. This evolution reflects a growing recognition of the importance of inclusive and comprehensive approaches in managing and controlling coastal reclamation, aligning with broader environmental conservation goals.

3.2 The core-edge structure of coastal reclamation policy network

Utilizing centrality analysis, we constructed a network diagram that vividly illustrates the intergovernmental relations and policy tools, clearly delineating their core and peripheral structures (Figure 5). This diagram reveals the intricate connections and hierarchies within the network.

To analyze this network, we employed a generative algorithm as a search method to produce a goodness-of-fit measure (Liu, 2019). The density matrix was then used to evaluate the fit of the block

TABLE 5 Centrality measurement results of policy tools.

Time	Policy tools	Degree	Closeness	Between
1978-1988	Goal Planning	0.333	0.565	0.000
	Policy Guidance	0.667	0.684	0.012
	Evaluation Mechanism	0.667	0.684	0.012
	Dynamic Regulation	0.667	0.684	0.012
	…			
1989-1998	Goal Planning	0.500	0.615	0.041
	Policy Guidance	0.500	0.615	0.007
	Dynamic Regulation	0.500	0.615	0.007
	Infrastructure	0.250	0.571	0.000
	…			
1999-2008	Overall Coordination	0.500	0.800	0.123
	Regulatory Control	0.625	0.842	0.061
	Goal Planning	0.625	0.842	0.078
	Evaluation Mechanism	0.875	0.941	0.176
	…			
2009-2017	Regulatory Control	0.565	0.718	0.186
	Goal Planning	0.565	0.718	0.116
	Evaluation Mechanism	0.478	0.681	0.078
	Dynamic Regulation	0.435	0.662	0.117
	…			
2018-2022	Regulatory Control	0.708	0.812	0.220
	Goal Planning	0.583	0.747	0.125
	Evaluation Mechanism	0.417	0.615	0.073
	Dynamic Regulation	0.458	0.709	0.104
	…			

…, Due to the excessive length of the data series, we sorted by numerical values and selected parts for display. This behavior had no influence on the analysis of results.

model. Although there was a discrepancy between the final fitting result and the ideal block, and the core-edge structure was not distinctly evident from 1978 to 1998 (Figures 5A, B), the policy network eventually demonstrated a pronounced "core" from 1999 to 2008 (Figure 5C), achieving a final fitting value of 0.85. The subsequent stages also yielded better fitting results (Figures 5D, E).

By 2022, we identified the core network, which encompassed 9 out of 22 government departments and 10 out of 16 policy instruments. This analysis provides a nuanced understanding of the evolving dynamics within the policy network, highlighting the key actors and tools that have shaped the landscape of reclamation management and control over the years.

The core-periphery analysis primarily concentrates on elucidating the interactions between policy tools and government departments. However, it is observed that this approach provides limited insights into the relationships among government departments themselves, as well as the interconnections between different policy tools. To address this gap, next, we extracted the first-mode network of intergovernmental relations from the broader second-mode network. This extraction allowed us to conduct a detailed cohesive subgroup analysis, thereby enabling a more focused exploration of the intricate dynamics within the network. Subsequently, we delved into the investigation of independent work cliques and uncovered the patterns of collaboration and coordination among these departments.

3.3 Cohesive subgroup formation of intergovernmental network

Through cohesive subgroup analysis using UCINET6 and NETDRAW software, we examined the evolution of factional relationships within the intergovernmental network in reclamation management activities. From 1978 to 1998, the network was predominantly dominated by a single faction,

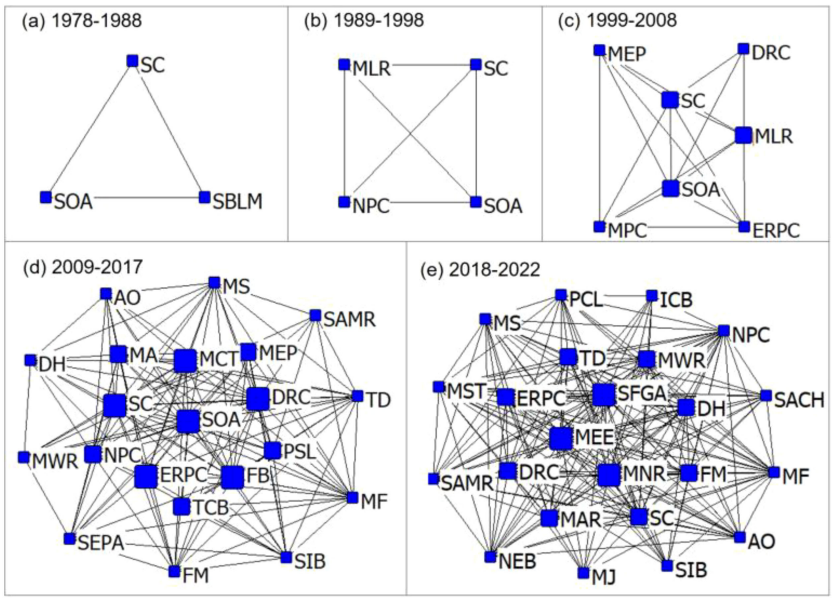

FIGURE 4
The evolution of intergovernmental relations in reclamation management and control policies from 1978 to 2022. **(A)** 1978-1988; **(B)** 1989-1998; **(C)** 1999-2008; **(D)** 2009-2017; **(E)** 2018-2022.

directly led by the Ministry of Land Resources and the Oceanic Bureau. From 1999 to 2008, environmental protection factions began to emerge. By 2017, the network expanded to 13 factions, and from 2018 to 2022, the number of factions reduced to 7. In the latter two stages, we focused our analysis on 4 typical factions to gain deeper insights into the roles and strategies of various government departments in reclamation control.

Since the 1970s, the Chinese government has implemented a paid reclamation policy to curb uncontrolled development, while generally still endorsing reclamation activities. In 1993, the "Interim Regulations on the Administration of the Use of National Sea Areas" were introduced, yet they lacked specific measures for reclamation control. Consequently, during this period (Figures 6A, B), the state's focus on reclamation management and

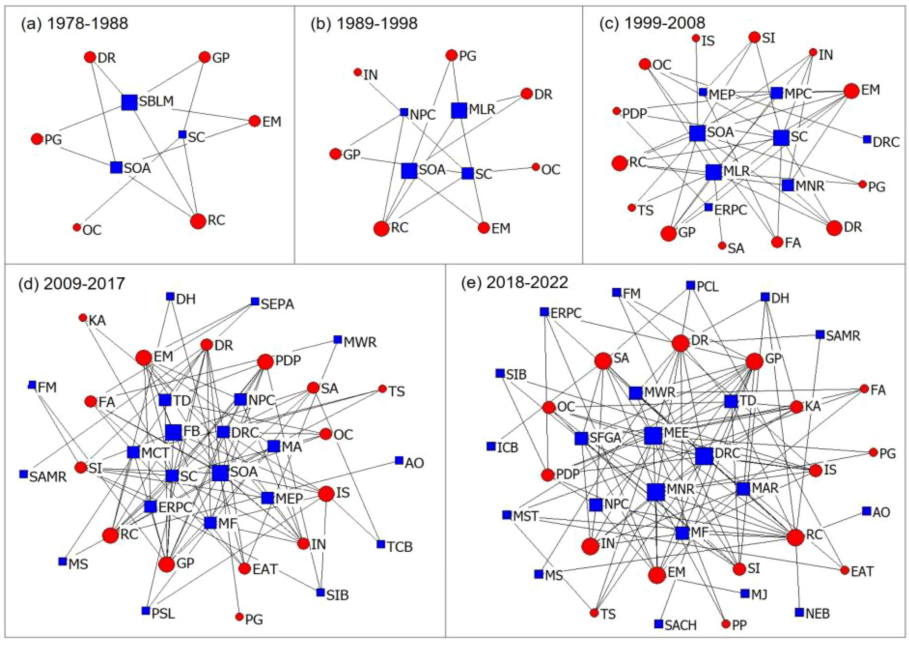

FIGURE 5
The core and peripheral structure of coastal reclamation management and control policies from 1978 to 2022. Note: Nodes from the core to the edge from large to small,red nodes represent policy tools,and blue nodes represent government departments. **(A)** 1978-1988; **(B)** 1989-1998; **(C)** 1999-2008; **(D)** 2009-2017; **(E)** 2018-2022.

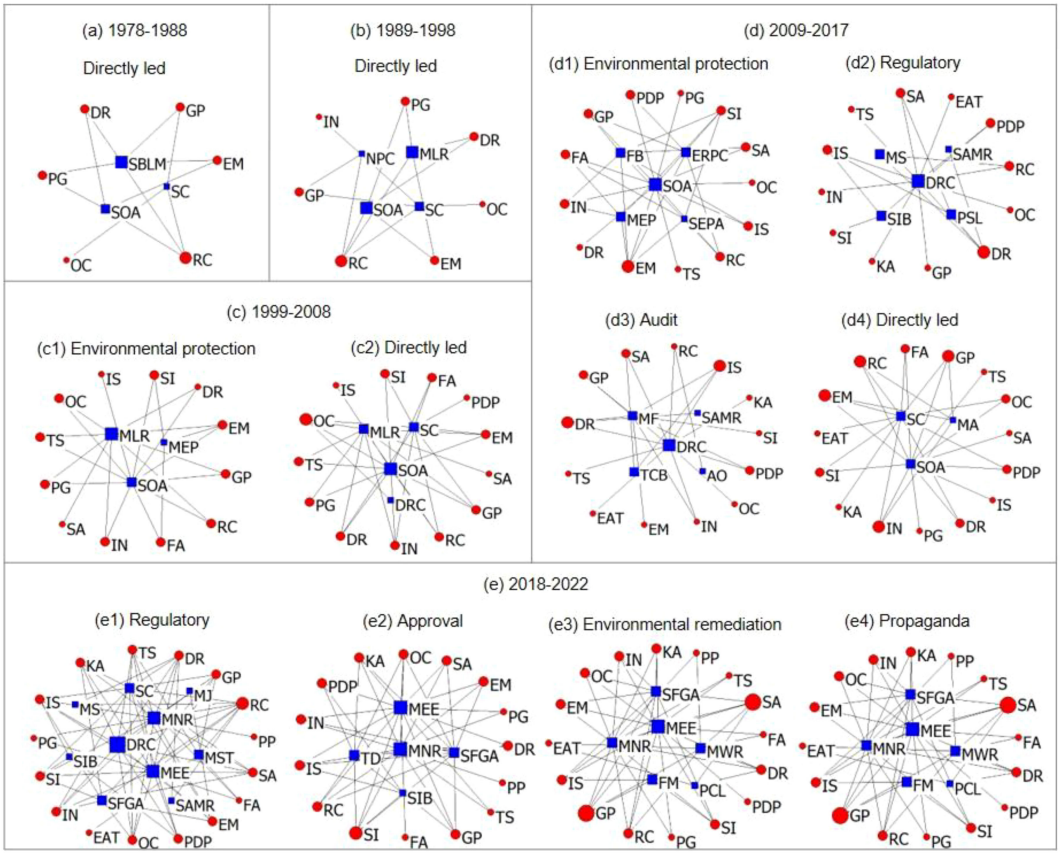

FIGURE 6
Evolution of cohesive subgroups in the different stages from 1978 to 2022. **(A)** 1978-1988; **(B)** 1989-1998; **(C)** 1999-2008; **(D)** 2009-2017; **(E)** 2018-2022.

control was limited, with predominantly singular policy tools and modest control effectiveness.

From 1999 to 2008, the rapid development of coastal regions and land resource scarcity triggered the fourth wave of coastal reclamation, drawing serious attention to the resultant marine ecological damage. An environmental protection faction, led by the former Ministry of Environmental Protection, the Oceanic Bureau, and the Environmental Resources Committee, emerged (Figure 6C). The establishment of environmental impact assessment mechanisms stringently controlled ecological damage from reclamation projects, while dynamic supervision was enhanced to monitor changes in reclaimed areas.

Between 2009 and 2017, despite the growth of the marine economy, rampant and unlawful reclamation activities became prevalent. The coastal reclamation policy shifted from a development-centric to a protection-centric approach, with increasingly stringent control measures, leading to the expansion of supervision and auditing factions (Figure 6D). The formation of these factions, particularly in auditing, was driven by the CNAO's emphasis since 2009 on the need for broader and more effective resource and environmental audits. The audits focused on land resource loss, waste, and ecological damage from key development activities like reclamation.

From 2018 to 2022, based on the common policy tool combinations in intergovernmental relations, factions 5 and 7 were identified as repair work and approval work factions, respectively (Figure 6E). These factions primarily focused on restoring the marine ecological environment and addressing historical issues from coastal reclamation. While the Audit Office was not a core department in the reclamation management and control faction, it collaborated with relevant departments to facilitate the smooth progression of reclamation management and control efforts.

4 Discussion

4.1 Balanced use of coastal reclamation management and control policy tools

The significance of social network analysis is that it can accurately quantify all kinds of relationships, so as to provide quantitative tools for the construction of certain theories and the test of empirical propositions. Policy tools in coastal reclamation management and control have evolved from a universal approach to a more targeted one, yet there has been an over-reliance on environment-side tools. During 1978-1998, the usage of environment-side tools constituted nearly two-thirds of the total policy tools, significantly outnumbering the other types (Figures 3, 6). Regulatory control and target planning were predominantly utilized, with the main policies being issued and

implemented by the State Council, indicating strong government intervention. However, this approach, based on the principle of parallel management and development, lacked specificity.

As the country intensified its focus on coastal reclamation management and control, specialized policies were progressively introduced, shifting the focus from broad macro-level directives to more detailed arrangements. Nevertheless, as the management and control situation grew increasingly complex, the demand for diverse management and control methods surged, revealing that the supply-side and demand-side policy tools were underutilized and insufficient to fully address the needs of coastal reclamation management and control. This led to an imbalance between supply and demand in later stages, resulting in excessive reclamation (Wang, 2016; Gu et al., 2018), idle reclamation resources (Wu et al., 2014), and improper utilization (Bi et al., 2012; Yan et al., 2023; Miao and Xue, 2021).

To address these challenges, a focus on the rationalization of factor allocation is essential to enhance supply efficiency. Government departments should actively manage the internal structure of both supply and demand sides, improve the support mechanisms for the coastal reclamation industry, and strengthen the supply side's stimulating effect on reclamation control demand. By aligning supply with demand, the capabilities of various government departments in providing services can be fully leveraged, thereby improving supply efficiency. Considering the historical legacy of coastal reclamation, it is vital to maximize the role of the market in resource allocation and integrate the stock of coastal reclamation resources as natural capital into the management and control policy framework.

4.2 The stability of the implementation of control policies needs improvement

The transition from cross-management to vertical management in coastal reclamation control has been evident, yet policy continuity remains a challenge. From 1978 to 2022, there has been a significant increase in government agencies involved in reclamation control (Figure 4). China signed the Ramsar Convention in 1992, drawing on the experience of global reclamation management, China's reclamation management has shifted from over-exploitation to protection, and the Forestry Administration is primarily responsible for the protection of reclaimed wetlands. In 2008, a pivotal shift occurred in the administrative efficiency of these departments, the marginal structure encompassed more government departments than policy tools, with each department utilizing most policy tools to fulfill management and control tasks, demonstrating a clear division of responsibilities. This shift indicates a simplification of administrative relations and an enhancement in administrative efficiency through vertical management, leading to a more structured approach to reclamation management and control. Subsequently, EU countries, like China, paid more attention to the balance between development and protection in the management of reclamation (Yang et al., 2022).

With the Fourth Ramsar Strategic Plan of 2016-2024 proposing efficient use of reclaimed wetlands, China put forward the concept of ecological civilization in 2015 to keep up with the global ecological protection situation. However, the entire process from policy release to actual implementation requires close attention. The policies are comprehensive and forward-looking, but there is a lack of supervision and accountability mechanisms (Li et al., 2020), resulting in inadequate post-event control capabilities. This issue stems from insufficient policy implementation control, reflecting a gap in management functions (Liu, 2021), and fails to effectively deter deviations in policy implementation behavior. To address these issues, it is crucial to optimize the management and control policy entities, improve the post-event management and control mechanisms, and enhance policy flexibility. The government should refine the personnel training mechanism for land reclamation management and control, fostering professional and technical personnel for marine standardization, and optimizing policy implementation bodies. This approach will contribute to the development of a more comprehensive and higher-level participation system. Additionally, the government should promptly identify and address problems. By increasing the issuance of joint documents by various agencies, the focus on post-event control mechanisms can be heightened, promoting a comprehensive approach that forms a closed-loop mechanism with pre-event and in-process controls, ensuring effective policy implementation. Simultaneously, it is essential to assess whether the positive and negative incentives within the policy content are balanced, focusing on reasonable matching and strengthening incentive policies such as reporting and supervision. This strategy will help to appropriately reduce the proportion of negative incentive policies, optimize the layout and structure of policies and regulations, and achieve effective policy implementation outcomes.

4.3 Coordination should be paid attention to in sea-use management

Work factions in coastal reclamation control have evolved from simplicity to diversity, yet conflicts between higher and lower-level laws persist. The continuous innovation in government departments has led to the formation of a social circle with the Ministry of Ecology and Environment, the Ministry of Natural Resources, and the National Development and Reform Commission as the absolute core. This circle, along with six relatively core departments like the Forestry and Grassland Bureau, collaboratively assists in the development of coastal reclamation control (Figure 5). However, policy effectiveness faces challenges such as conflicts between higher and lower-level laws and unclear divisions of sea area use rights.

In 2018, the "Notice on Strengthening the Protection of Coastal Wetlands and Strictly Controlling Coastal Reclamation Work" mandated that, barring major strategic projects, the approval of reclamation projects would be entirely suspended, centralizing approval powers with The State Council. However, coastal provinces continue to implement regulations based on the "Law on the Administration of the Use of Sea Areas" enacted by the National People's Congress, due to its higher legal standing than State Council regulations. Current coordination measures are

insufficient, and there is significant variation among coastal provinces in the division of sea use approval authority. For instance, Guangdong and Jiangsu have different thresholds for the size of sea areas requiring approval for government projects. This disparity in authority division leads to confusion in sea use management and complicates the resolution of historical reclamation issues.

As the "Sea Area Use Management Law" is being implemented across various provinces, its internal and external contradictions need effective resolution. The debate over prioritizing the effectiveness, applicability, or newness of laws persists (Shi et al., 2010). However, it is clear that higher-level laws should always form the basis for legal effectiveness. Lower-level laws should align with the methods and content of higher-level laws, and the principles of "application priority" and "new law priority" should only apply when lower-level laws are consistent with higher-level ones (Wu, 2010). The government should promptly follow up on target policies, address implementation barriers, and ensure the effectiveness and continuity of policy implementation.

5 Conclusion

From 1978 to 2022, China's coastal reclamation management and control policies have significantly evolved, showing increasing complexity in intergovernmental relations and a growing emphasis on environmental policy tools. This study, employing content and social network analysis, reveals a shift from simple structures to complex networks involving multiple government departments and diverse policy tools. This shift is marked by the growing importance of key departments like environmental protection, land management, and marine affairs. The shift from traditional development-focused to environmentally-conscious policies is evident. The increased use of environmental tools highlights an imbalance with other policy tools. While policies indirectly managing reclamation through texts are forward-looking, they face sustainability challenges.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Author contributions

HG: Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. XH: Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JL: Data curation, Formal analysis, Methodology, Resources, Validation, Writing – review & editing. PT: Data curation, Formal analysis, Investigation, Methodology, Software, Writing – review & editing. SA: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – review & editing. YL: Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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