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Promoting environmental sustainability through interorganisational education: A network analysis of China's blue sky action plan

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Abstract:
The pursuit of Beautiful China has emerged as a national aspiration among the Chinese populace. The sustainable objective is an essential component of China's modernisation process, necessitating both individual and institutional education to promote the harmonious coexistence of humanity and nature. This study offers a micro analytical framework for examining air quality governance in China's rapidly growing megacities, shedding light on the multi-scalar, multi-sectoral learning that shape collaborative policymaking at the local level. Drawing upon a blended methodology of social network analysis and semantic network analysis, the paper presents a granular, empirically-grounded account of the institutional arrangements, policy instruments, and discursive frames underlying Shenzhen's comprehensive approach to tackling air pollution challenges. The findings demonstrate the highly educated and coordinated nature of the city-level environmental governance strategy, which harnesses a diverse array of collaborative learning platforms, development-oriented education, and large-scale infrastructure projects across key sectors such as transportation, industry, and urban planning. This study contributes to elucidating the contextual factors, institutional configurations, and interorganisational learning that shape the evolution of collaborative education in diverse urban settings across the developing world.

1. Introduction

Since the 18th National Congress of the Communist Party of China, the country has intensified its efforts to advance the construction of an ecological civilization. Within this broader initiative, the significance of education has been continuously emphasized and accentuated. Particular emphasis has been placed on integrating ecological civilization education into the comprehensive process of human capital development, thereby furnishing multifaceted talent, providing China's unique wisdom and solutions for global ecological governance and the advancement of ecological education on an international scale.

Ecological civilization education encompasses a dual focus within the broader effort to construct an ecological civilization in China. On one hand, it calls for strengthening school-based education to enhance individual environmental awareness and consciousness. On the other hand, it emphasizes the importance of top-level strategic planning and coordination in the domain of ecological civilization education (Klemow et al., 2019). This latter emphasis underscores the need for inter-organizational collaboration and harmonization across different governmental departments and administrative regions. By cultivating environmental awareness, knowledge, and sustainable values through educational means, the Chinese government aims to catalyse a profound shift in the way society interacts with the natural environment.

China is grappling with the complex challenges of air pollution and climate change, which are emblematic of the 'wicked problems' that require concerted efforts and mul-

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tifaceted policy approaches (Agostinis & Urdinez, 2024). Addressing these issues necessitates collaborative mechanisms involving local governments and a diverse portfolio of policy instruments. This study investigates the collaborative endeavours in air pollution management within China. By employing a mixed-methods approach that encompasses both Social Network Analysis (SNA) and Semantic Network Analysis (SNA), we aim to delineate the cooperative network among government departments and construct a semantic network of policy texts. The research objective is to explore a case study of environmental governance in Shenzhen, focusing on cooperative frameworks and the array of policy instruments utilized to address environmental concerns.

The majority of governments primarily address environmental challenges through the formulation and implementation of environmental policies. Consequently, scholarly interest in the study of environmental policies and their efficacy has been pronounced over recent decades (Sommerer & Lim, 2016). The literature on policy design has predominantly centred on the impact of policy instruments on policy outcomes, while the implementation literature has primarily focused on analysing factors that impede the effective operation of environmental policies in practice. These factors include administrative capabilities, policy venues, and the influence of interest groups (Steinebach, 2022). Despite notable progress, there is a dearth of research examining the interaction between interorganizational collaboration and the diverse types of informational policy instruments implemented at the local level. As China's transition to a green economy and pursuit of low-carbon development continue, it poses a significant challenge to investigate the policy strategies and collaborative actors across various dimensions, including carbon peaking and neutrality, the optimization of industrial structures, and the enhancement of resource utilization efficiency (Coenen et al., 2021).

As China has implemented environmental schemes on an unprecedented urban scale, there is growing scholarly and civil society concern regarding the interorganizational education, learning processes, and sustainability outcomes of these initiatives. While the Chinese government has placed increasing emphasis on the role of ecological education in national-level policy, scholarly analyses of environmental practices in China have yet to fully incorporate these emergent policy strategies. Existing scholarship has tended to concentrate on more tangible, observable environmental initiatives, such as technological innovations, regulatory mechanisms, and infrastructure development, while neglecting the crucial role of human capital development and the alignment of organizational mindsets (Hung, 2019). To further contribute to global environmental sustainability and the national achievement of low-carbon objectives, there is a pressing need for further exploration into effective collaboration models.

This study offers an initial assessment of the emerging environmental governance framework of Shenzhen's 'Blue Sky Sustainable Action Plan,' encompassing the structure, evolution, and functionality of the interorganisational learning network. We pose two principal questions: (1) What are the key sectoral actors involved in ecological learning for environmental governance? (2) What policy instruments have been adopted by decision-makers to effectively foster mutual education and learning among diverse stakeholders? This study aims to elucidate the strategies and repercussions of cooperative governance from a municipal viewpoint within a non-Western context, thereby providing insights into the governance mechanism within a global milieu.

2. Literature review

2.1 Environmental collaborative governance

The scholarly literature on environmental governance has evolved significantly in recent decades, drawing on a diverse array of theoretical frameworks and empirical case studies. Theories of Metropolitan Government, rooted in the mid-20th century consolidation of urban administrations, have emphasized the benefits of scale economies and coordinated policy-making across fragmented local jurisdictions (Dolan, 1990). In contrast, Public Choice models have highlighted the virtues of institutional competition and the dangers of monopolistic regional governments (Ge et al., 2021). More recently, new perspectives have shifted the focus towards networked, polycentric forms of governance that transcend traditional boundaries, embracing cross-jurisdictional collaboration and the diverse stakeholders shaping metropolitan dynamics (Addie, 2013). Furthermore, the Reterritorialization framework has problematized the very notion of fixed regional scales, drawing attention to the fluid, contested, and multi-scalar processes through which political-economic spaces are continually (re)produced (Elden, 2022). Collectively, these theoretical paradigms have yielded important insights into the complexities of environmental governance at local and regional level, illuminating the variegated organizational structures, power relations, and socio-spatial transformations unfolding across urban agglomerations worldwide.

In China, where the market system is under-developing and non-governance actors are relatively weak, the multi-layer government plays a dominant role in economic, social, and ecological matters. The central government is more accustomed to a top-down, campaign-based model of governance (Zhan & Qin, 2017). Scholars have analysed the importance, limitations, and reasons for inter-municipal cooperation in Chinese environmental governance. Transaction cost theory has been employed to examine the economic incentives and organizational efficiencies that drive local governments to pool resources and coordinate their environmental policies and regulatory enforcement (Deng & Zhang, 2020). Game theory has shed light on the strategic interactions and collective action dilemmas with divergent interests and priorities (Liang et al., 2019). The Institutional Collective Action framework has illuminated the role of intergovernmental structures, leadership, and trust-building in overcoming barriers to collaborative environmental governance across jurisdictional boundaries (Yi et al., 2018). Moreover, the collaborative governance studies in China have also emphasized the importance of inclusive, deliberative decision-making processes that engage a broad spectrum of non-state stakeholders in the co-production of sustainable regional policies (Arantes et al., 2020).

Scholars have presented divergent views on the efficacy of cooperation within environmental governance frameworks. Empirical studies have highlighted the substantial cost savings and positive environmental impacts associated with inter-provincial collaboration, which encourage further collective action to mitigate environmental challenges (Xue et al., 2015; Yi et al., 2018). Conversely, other research indicates that collaborative governance faces ongoing challenges, particularly when cities of similar political stature engage in cooperation. Such endeavours may be impeded by local officials' promotion incentives and the fiscal decentralization policies that shape their behaviour (Chen et al., 2017). Furthermore, vertical intergovernmental collaboration has been correlated with a negative impact on economic growth, suggesting a complex interplay between governance structures and economic outcomes (Cui & Wang, 2020).

Pervious research on environmental collaborative governance has predominantly adopted a macro perspective, examining inter-city government cooperation mechanisms with a particular emphasis on the rationale behind cross-border cooperation in China's air pollution initiatives. However, the execution of these policies necessitates enhanced collaboration among internal city stakeholder, which has received less scholarly attention. This study seeks to address this research gap by constructing a network analysis of intra-city cooperation from a meso and micro perspective.

2.2 Policy instruments in environmental governance

China's longstanding struggle with air pollution and climate change has prompted a shift in the country's governance strategies and policy instruments, with local governments increasingly turning to regional cooperation and cross-regional interventions as a means of addressing these pressing environmental challenges. However, the limitations of such siloed strategies have become increasingly apparent. As air pollutants continue to transcend administrative borders, , there is a growing imperative for a more coordinated, multi-scalar policy strategies (Liu et al., 2018). In recent years, China has thus witnessed a notable transition, with national policies and pilot programmes actively promoting local environmental sustainability (Liu et al., 2022). The emergent governance models encompass joint enforcement mechanisms, shared education and learning systems, and concerted efforts to prevent and control air pollution on a regional scale, harnessing the complementary capabilities and resources of neighbouring municipalities (Mu & Cui, 2024).

The establishment of a cooperative joint prevention and control system for environmental governance in China represents a long-term, comprehensive, and intricate systematic endeavour (Zhao et al., 2013). While this mechanism has demonstrated notable success, with studies utilizing quasi-natural experimental methods confirming substantial reductions in PM2.5 concentrations-the primary pollutant target of the system (Feng et al., 2021)-it is imperative to acknowledge that effective coordinated air pollution control hinges on the alignment of interests (Wu et al., 2020). Regional disparities in economic development levels, environmental capacities, industrial structures, and the self-interests of local officials further complicate these coordination efforts, especially when spanning across different administrative jurisdictions (Wang & Chang, 2014).

Extant literature has predominantly focused on examining the policy instruments employed by the central government in China, emphasizing the roles of legal, financial, and industry-based regulations (Wang & Chang, 2014; Jiang & Tang, 2023). However, more recent studies have found that such regulatory instruments have had limited outcomes in promoting enhanced environmental performance. Scholars have observed that command-and-control type instruments have had a positive effect on driving green process innovations, but have lacked significance in promoting the development of clean production technologies and products (Shen et al., 2020). Furthermore, researchers have highlighted that configurations of policy instruments and network collaboration can serve as sufficient conditions for achieving high environmental performance (Liu et al., 2024). Particular emphasis has been placed on understanding locally-specific configurations, especially regarding lesser-studied policy instruments such as information provision for environmental sustainability in inter-organizational collaborations.

This study adheres to the well-established theoretical framework of policy instruments as articulated by Howlett & Rayner (2013)to discern the keywords associated with three distinct policy instruments. Reflecting on extant research, China's strategy for addressing environmental challenges has evolved from centralized control mechanisms to localized and regional pollution prevention and control efforts (Kostka & Nahm, 2017). Concurrently, the policy instrument mix has shifted from a singular regulatory focus to a more heterogeneous array of policy tools. To evaluate the diversity of policy instruments within policy documents, this research categorizes them into three intervention levels: regulatory, market-based, and information-education policy instruments. This taxonomy is consonant with the institutional context of the Chinese government.

3. Research methodology

3.1 Case selection

As the world's most populous developing nation, China has grappled with the dual challenges of rapid urbanization and industrialization, which have precipitated severe air pollution crises in many of its metropolitan regions (Dong et al., 2021). Amidst this broader national context, the case of Shenzhen offers a particularly salient example, highlighting both the complexities of addressing air quality issues in the face of breakneck socio-economic transformation, as well as the potential for innovative local governance approaches to yield tangible and sustainable improvements.

Over the past four decades, Shenzhen has undergone a remarkable metamorphosis, evolving from a modest fishing village into a globally-connected megacity that now serves as the core of the broader Greater Bay Area urban agglomeration. While this remarkable urban development trajectory has

Table 1. Co-occurrence matrix for government departments of the Shenzhen Blue Sustainable Action Plan (partial).

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
D1	0	35	21	15	14	9	9	10	10	6
D2	35	0	15	12	5	8	12	11	10	3
D3	21	15	0	9	13	5	15	6	13	10
D4	15	12	9	0	5	2	6	2	6	3
D5	14	5	13	5	0	2	2	2	2	3
D6	9	8	5	2	2	0	2	9	0	2
D7	9	12	15	6	2	2	0	3	12	3
D8	10	11	6	2	2	9	3	0	2	1
D9	10	10	13	6	2	0	12	2	0	2
D10	6	3	10	3	3	2	3	1	2	0

catalysed remarkable economic growth, it has also exacerbated environmental degradation, prompting the municipal government to implement a raft of targeted policies and initiatives to address the city's air pollution woes in the last decade and achieve success in air quality recovery efforts (Xu et al., 2022).

Specifically, the Shenzhen Municipal Ecology and Environment Bureau has released the draft of the "Shenzhen Blue Sustainable Action Plan (2022-2025)", which includes eleven key tasks aimed at improving the city's air quality. In this paper, we will use this policy as a textual case study for the analysis of cooperative networks to explore the operation of environmental collaboration mechanisms and policy toolboxes in the context of urban governance in China's megacities. As a leading city within China's regional integration initiative, Shenzhen's air governance framework and practices may also serve as a model for coordinated environmental management across the Greater Bay Area (GBA) and beyond.

3.2 Research methods

This study draws upon a multi-pronged analytical approach to examine the empirical case of Shenzhen's environmental collaborative governance mechanisms. The data source for the analysis comprises policy documents downloaded from the official website of the Shenzhen Municipal Government, which are subjected to a two-pronged analytical framework blending social network analysis (SNA) and semantic network analysis (SemNA). Ucinet software was utilized for data visualization.

Social network analysis, rooted in the sociological tradition, offers a robust set of methods for mapping and interpreting the intricate web of relationships among diverse stakeholders involved in environmental governance initiatives (Dowding, 1995). By representing these stakeholder networks through visual diagrams, SNA provides a clear and intuitive understanding of the structural dynamics and power dynamics shaping collaborative environmental policymaking and implementation (Tabassum et al., 2018).

Complementing this structural analysis, semantic network analysis harnesses computational text mining techniques to systematically extract, organize, and interpret the discursive frames and meaning-making processes embedded within policy documents (Lee & Son, 2017). This integrated methodological approach enables a multi-scalar examination of Shenzhen's environmental governance architecture, illuminating both the relational configurations of key actors as well as the underlying conceptual logics and linguistic framings that inform policy narratives and priorities.

Overall, these analytical techniques facilitate a nuanced, empirically-grounded investigation of Shenzhen's environmental collaborative governance mechanisms, offering valuable insights into the structural, institutional, and discursive dimensions shaping the city's pursuit of sustainable development within the broader context of China's regional integration initiatives.

4. Results

4.1 Cooperative network of local departments

Within the policy action plan, each specific task and measure is assigned to lead responsible agencies and cooperating entities. These departments coordinate their progress through a joint meeting system and fulfill their responsibilities within the framework of ecological civilization construction assessments. For instance, the Environmental Bureau, urban management teams, and the Shenzhen Energy Group share joint accountability for the modernization of waste incineration facilities.

To enhance readability, this study assigns codes to participants, and the resulting co-occurrence matrix is presented (see Table 1). Given that sectoral cooperation is undirected, the network under analysis is a one-mode network, characterized by a symmetric matrix along the diagonal. The diagonal values represent the frequency of interactions between pairs of sectors. Owing to the multitude of participants in the network, a selection is made for presentation in this paper, ordered by the centrality measures derived from the analytical procedures.

As illustrated in Table 2, the social network analysis of Shenzhen's environmental governance framework reveals a complex network of institutional actors, highlighting the

Table 2. Network point centrality.

Code	Departments	Degree	NrmDegree	Share
D1	Ecological Environment Bureau	166.000	15.300	0.134
D3	Transportation Bureau	149.000	13.733	0.120
D2	District Governments	147.000	13.548	0.118
D7	Housing and Construction Bureau	93.000	8.571	0.075
D9	Water Authority of Shenzhen Municipality	80.000	7.373	0.064
D4	Market Supervision Administration	75.000	6.912	0.060
D8	Industry and Information Technology Bureau	65.000	5.991	0.052
D5	Public Security Bureau	62.000	5.714	0.050
D6	Development and Reform Commission	55.000	5.069	0.044
D10	Shenzhen Maritime Safety Administration	44.000	4.055	0.035

multifaceted and interdependent nature of collaborative policymaking within the region. The network analysis identifies 32 distinct actors within the Shenzhen network map, including representatives from the environmental bureau, market regulation department, social development division, and information technology bureau.

The overall network density, calculated at approximately 0.3199 with 388 connections, indicates a moderately high degree of interconnectedness among these entities. Generally speaking, the density value ranges from [0,1], suggesting the existence of relatively robust channels for information sharing and learning, resource mobilization, and joint decision-making. Network centrality analysis revealed that the Ecological Environment Bureau exhibited the highest degree of centrality within the interorganizational collaboration network. This suggests the bureau may be the most influential entity, responsible for coordinating information sharing and educational initiatives with other actors regarding relevant environmental objectives. Other central organizations included the Transportation Bureau, District Governments, and Housing and Construction Bureau.

Employing Ucinet's network mapping function, we have generated a visual representation of the cooperation network among Shenzhen's air governance sectors (see Fig. 1). This network diagram exhibits a distinct core-edge structure, where each node denotes a sector and the connecting lines between nodes signify the extent of their collaborative interactions. Through the aggregation analysis of the network, distinct clusters are discernible, for instance, the two red-marked clusters correspond to the priority tasks of "Low-carbon transformation of the energy supply system" and "Construction of green transportation" are the two key aspects.

4.2 Semantic network of policy instruments

Based on the social network analysis results, this study discerns 50 specific policy projects by filtering out broad or irrelevant sections, such as 'guiding ideology' and 'general requirements.' Subsequently, a word frequency statistics tool was employed to conduct a keyword frequency analysis of the document, which is organized in a descending order table of verbs and nouns. The word frequency table underwent further refinement, including the exclusion of Chinese conjunctions or filler words and the consolidation of synonyms, to yield a list of the 10 most frequently occurring words in the policy document, as presented in Table 3. This frequency table delineates the recurrence of each word within the policy initiative, with the values reflecting the centrality of the words within the semantic network.

This study proceeded to examine the co-occurrence of these lexical items. The co-occurrence matrix delineates which Chinese words appear concurrently within policy projects or sentence clusters (semantic units). Semantic analysis suggests that noun phrases typically denote specific public issues and thematic areas, while verbs are indicative of policy instruments and strategy preference. The combination of specific nouns and verbs reveals a pattern of 'action-policy topic' integration. Consequently, this paper engaged in manual coding to identify verb-noun pairings. Table 4 presents the top 10 verb-noun match matrices, with the network characterized as bimodal and undirected, where the x-axis and y-axis represent distinct types of nodes.

The network visualization presented in Fig. 2 offers a comprehensive mapping of the policy instruments and sectoral domains mobilized by the Shenzhen Municipal Government in its efforts to address the city's air quality challenges. On the one hand, Shenzhen strictly controls the sources of pollution and process management in the energy, industry, and transportation sectors through regulatory policies in air quality governance. This includes the development of strategic emerging industry clusters in Shenzhen, the construction of advanced manufacturing parks, and the creation of smart workshops and green factories to reduce industrial energy consumption. In policy documents, verbs such as 'governance', 'regulate', and 'monitor' are typically directed towards the control of local enterprises and the maintenance of environmental quality. These terms underscore the administrative efforts to oversee and manage business practices and environmental standards within a region.

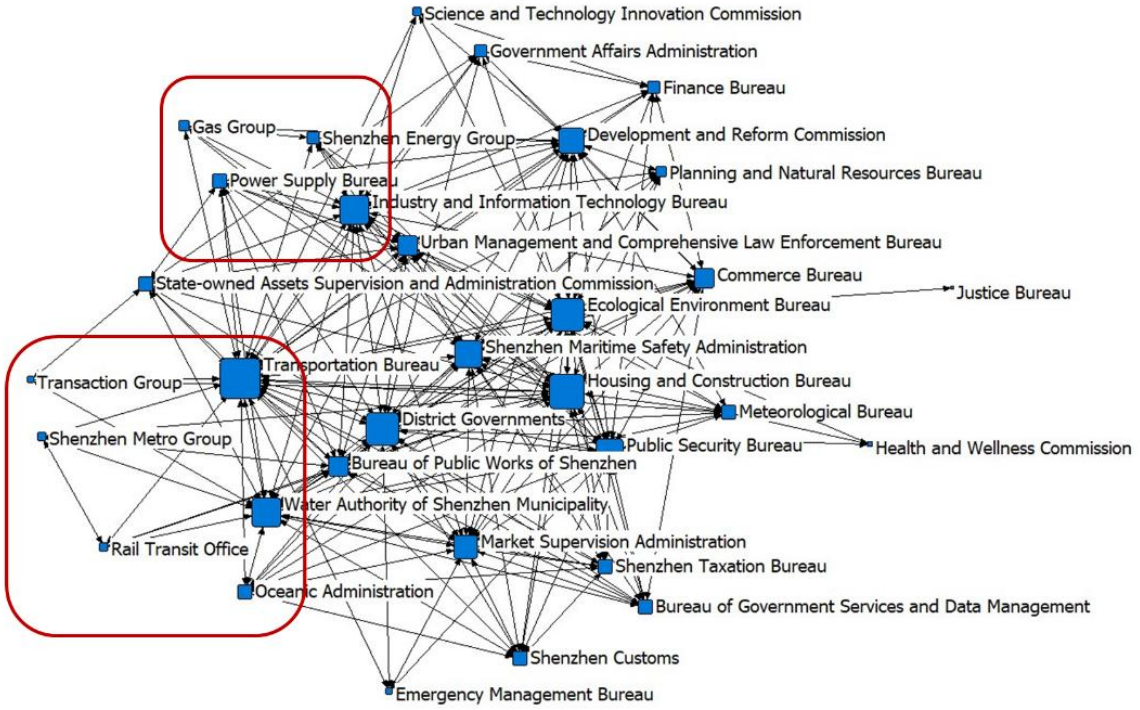

Fig. 1. A social network of Shenzhen sectors involved in air pollution governance.

On the other hand, market-based policies have also been emphasized in forming the collaborative networks, such as incentives in industry, finance, taxation, and other approaches to encourage manufacturing firms to transition and upgrade towards greener practices. Furthermore, the verb 'construct' extends beyond the realm of urban renewal to encompass the development of environmental education and information platforms aimed at enterprises, citizens, and communities. This verb-noun pairing signifies a broader strategy to bolster social norms regarding environmental protection and sustainability, facilitating the dissemination of knowledge and the promotion of eco-friendly practices among various societal groups.

Notably, the policy instruments adopted in the Shenzhen case emphasized informational and educational strategies. Verbs like 'target' and 'research' are often paired with educational platforms, exemplified by specialized classes on Hong Kong-Shenzhen environmental cooperation and the Hong Kong-Shenzhen Environmental Cooperation and Exchange Meeting. These pairings highlight the pivotal role of Shenzhen as a 'Belt and Road' hub for Environmental Technology Exchange and Transfer Center, emphasizing its commitment to regional academic and technological collaboration on environmental issues.These aimed not only to enhance public awareness, but also to facilitate emission-related education within the interorganizational network. The policy framework further called for strengthened monitoring of air quality by key stakeholders, as well as improved sharing of environmental data and resources to promote cross-organizational learning.

The network diagram illustrates the breadth and interconnectedness of the policy portfolio, encompassing a diverse array of interventions across the transportation, industrial, market, and social sectors-all of which are recognized as critical components of effective air quality governance. Prominent among the policy instruments employed were information and educational strategies focused on facilitating inter-organizational cooperation, aligning social and industrial development with environmental sustainability objectives, and managing large-scale infrastructure construction projects.

5. Discussion: advancing interorganizational education within network governance

The integrated analysis of Shenzhen's environmental governance network reveals the increasing emphasis placed on informational-education policy instruments to address the city's air quality challenges. Specifically, the findings highlight the growing importance of inter-organizational education initiatives and collaborative learning platforms as key components of the municipal government's environmental governance strategy. Establishing cross-sectoral coordination mechanisms, such frequent policy discussions and collaborative working groups, would help the Shenzhen Environmental Bureau improve collaboration with other sectors. By facilitating resource sharing and information exchange, these channels can improve policy synergies and assist in resolving disagreements in the execution of policies.

The social network analysis highlights the extensive web of institutional collaborations, underscoring the highly interconnected nature of Shenzhen's air quality management efforts. In addition to the traditional departmental actors identified, such as those from the environmental, transportation, and water management bureaus, the information and technology bureau also exhibited an increasing role within the collaborative

Table 3. Descending list of 10 most frequent words.

Descending	list of	10	most	frequent	words
V1	Governance	38	N1	Enterprises	31
V2	Regulate	23	N2	Road	22
V3	Monitor	21	N3	Vessel	18
V4	Target	20	N4	Green	15
V5	Manage	16	N5	Region	14
V6	Research	14	N6	System	14
V7	Construct	14	N7	Vehicles	13
V8	Phase out	11	N8	Refined oil	14
V9	Standard	7	N9	Emissions	11
V10	Emergency response	7	N10	Construction site	11

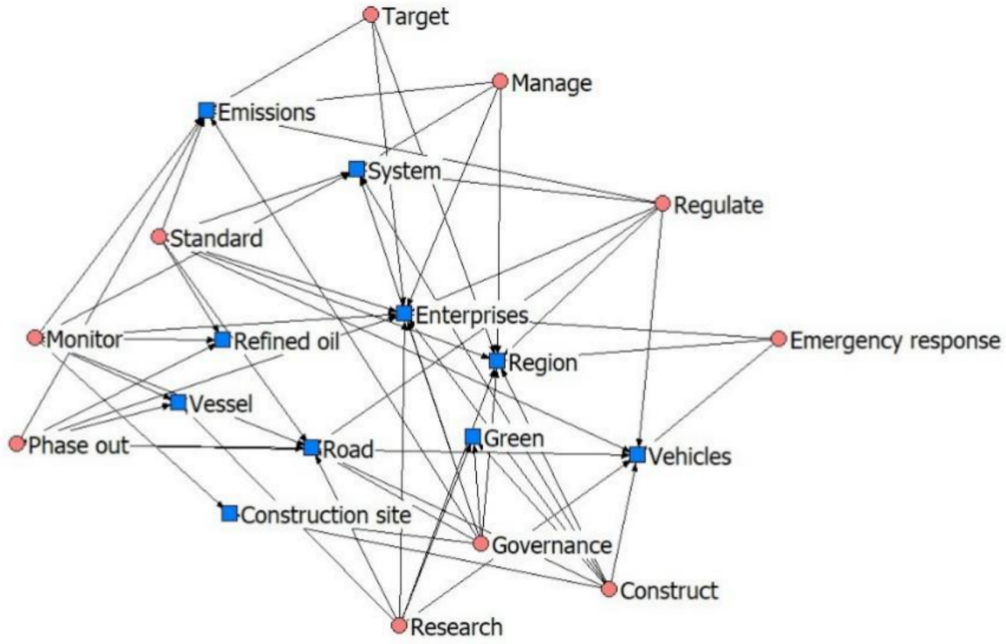

Fig. 2. Semantic network of policy text.

governance networks. This bureau frequently co-occurred with the aforementioned functional and professional departments. The emerging feature of the identified governance network points to a growing emphasis on technological education, mutual learning initiatives, and cross-stakeholder information sharing in policy implementation at the municipal level. This finding aligns with existing research on environmental governance within China's Belt and Road Initiative, which has also identified a national-level strategy oriented towards an institutional architecture based on information-sharing and educational instruments. These include the use of aspirational vision statements and voluntary mechanisms, rather than solely relying on traditional regulatory approaches (Coenen et al., 2021).

The semantic network analysis illuminates the substantive content and conceptual framing of the policy instruments deployed within this collaborative framework. The policy texts continued to demonstrate the centrality of command-and-control instruments, such as regulations and monitoring/management strategies. However, informational and educational policy instruments were also prominently featured, as evidenced by the frequent appearance of keywords like "standard" and "research" in the relevant initiatives. These informational tools often targeted broader social systems and enterprises, rather than being limited to government departments alone. Consistent with the provincial-level findings, the increasing prominence of informational and educational policy instruments could potentially exacerbate regional inequalities in environmental governance within China's multilevel system (Lihua et al., 2020).

Table 4. "Action-Themes" two-mode network: a policy tool perspective.

	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10
V1	28	1	0	4	3	14	0	0	26	5
V9	3	5	0	0	1	27	2	1	3	0
V3	12	5	4	0	0	7	0	1	2	4
V7	13	2	0	10	1	6	1	0	0	8
V2	7	3	0	0	2	6	2	0	3	0
V6	3	1	1	4	1	0	1	0	0	0
V5	1	0	0	0	1	1	0	0	1	0
V8	2	8	3	0	0	0	5	2	4	0
V10	1	0	0	0	10	0	1	0	0	0
V4	2	0	0	0	6	0	0	0	3	0

The identified cooperative arrangements and collaborative network suggests a concerted effort by the Shenzhen government to foster cross-sectoral learning platform and stakeholder alignment in the environmental sustainability missions. Likewise, the emphasis on development and reform-oriented initiatives points to a developmental state approach, wherein the municipal authorities leverage their regulatory and fiscal capacities to catalyse technological learning, industrial restructuring, and interorganisational information sharing aligned with environmental sustainability objectives. Notably, the prominence of informational and educational instruments within the network underscores the continued salience of interorganisational learning and interventions-such as the advocacy for sustainable objectives and the development of crosssector information sharing platforms-as key pillars of Shenzhen's multi-pronged air quality management strategy.

Drawing on the institutional and interest group theories, our analysis posits that local government institutions do not operate exclusively on the principle of efficiency (Stokes, 2020). Instead, their behaviors and decision-making processes are significantly influenced by a multitude of external factors, including regional cultural norms, local citizen expectations, and national regulatory frameworks. Moreover, we contend that organized interest groups play a pivotal role in shaping local policy development and in revealing new power dynamics within the policy-making arena. These groups, through their advocacy and lobbying efforts, can either reflect or challenge the institutional status quo, thereby influencing the trajectory of policy outcomes and the distribution of resources within the community (Zhang & Zhu, 2020).

In this study, we identified the pivotal roles of the Transportation Bureau and the Housing and Construction Bureau in environmental governance, complementing the traditional focus on the Environmental Bureau and local district governments. The Transportation Bureau's influence in environmental governance is manifested through the establishment and enforcement of stringent environmental regulations for transportation infrastructure projects. This encompasses the integration of environmental criteria into the contract evaluation and award process, as well as the execution of projects, ensuring that ecological impacts are minimized and mitigated. Similarly, the Housing and Construction Bureau can significantly contribute to environmental governance by advocating for green building certifications and endorsing sustainable construction practices. The involvement of multiple local bureaus in environmental governance necessitates a heightened focus on inter-organizational education and collaboration.

6. Conclusion

The insights gleaned from this study underscore the importance of inter-sectoral and inter-regional coordination and integration as core elements of Shenzhen's local environmental governance strategy. Additionally, the research highlights the significance of a well-organized, coherent educational framework in the city's overarching approach.

The findings reveal that this cross-sectoral network relies on an effective combination of multi-level policy instruments targeting diverse stakeholders, with informational and educational tools playing a particularly prominent role. The strategic deployment of these policy levers reflects a recognition that addressing complex environmental challenges requires not only top-down directives, but also the active engagement and alignment of various societal actors.

However, the ultimate effectiveness of this policy toolkit such a cross-sectoral network hinges on the capacity of municipal authorities to orchestrate and sustain these initiatives amidst the intricate socio-spatial dynamics that characterize the urban environment. Navigating the complex web of inter-organizational education network and aligning diverse interests pose ongoing challenges that require robust governance capacities and coordination mechanisms.

Future governance strategies should aim to foster cooperation by organizing training courses and seminars, which not only raise public awareness but also enhance cross-sector understanding of local environmental standards and acknowledge the spatial spillover effects of environmental policies. By emphasizing the collaborative efforts of these key stakeholders, our research highlights the multifaceted approach required for

effective environmental governance, moving beyond the scope of traditional environmental management to include a broader spectrum of governmental and institutional actors.

While the study offers valuable insights into the localized dynamics and nuances of air quality management in a Chinese megacity context, the authors acknowledge the limitations inherent in the reliance on a single methodological approach and the potential biases introduced by the specific policy document dataset analysed. Future comparative research with other Chinese megacities may offer a more thorough analysis and uncover more general trends or variances in collaborative governance techniques across other urban environments. Future research would benefit from the incorporation of analytical techniques, such as comparative case studies and more granular categorizations of policy instruments, to further enhance the evidence base and generalizability of the proposed framework.

Conflict of interest

The authors declare no competing interest.

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