Adaptive Planning in China: Research Progress, Implementation Effectiveness, and Future Prospects Based on Knowledge Mapping and Meta-Analysis

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Abstract
Adaptive planning aids in addressing nonlinear urban changes through dynamic adjustments. This study employs knowledge mapping and meta-analysis methods to examine the progress and effectiveness of adaptive planning research in China over the past two decades. The results indicate that China has focused on the application of adaptive planning in environmental areas, gradually expanding to territorial spatial planning. Key areas of focus include ecological protection, urban renewal, and transportation development. The overall effectiveness of adaptive planning implementation in China has been positive, though attention is needed on developing multiple alternative plans, enhancing community participation, and increasing long-term investment in adaptive processes. This study identifies adaptive issues and response strategies within the Chinese planning context, aiming to enrich the global research system of adaptive planning.

Keywords
adaptive planning; Chinese practice; research progress; implementation effectiveness

1. Introduction

Global cities are facing profound uncertainties in economic development, environmental climate, public health, infrastructure, and other aspects, posing unprecedented challenges for urban planning. Adaptive planning, as an innovative planning concept, is increasingly receiving attention in academia. Due to its dynamic evolution and the involvement of multiple stakeholders, adaptive planning can assist cities in overcoming short-term uncertainties and create sustainable long-term futures through dynamic adjustments.

In recent years, international research on adaptive planning has been gradually increasing, encompassing diverse disciplines, theoretical foundations, and technological levels. Apart from the typical adaptation to climate change studies(Ahern, 2011; Cai and Wen, 2017), other research focuses on adaptive governance of urban built environments. From the perspective of community participatory planning, discussions revolve around governance strategies concerning sea-level rise(Vella *et al.*, 2016), policy logic(Urwin and Jordan, 2008), ecological resilience in urban design(Ahern, 2013), and the adaptive governance process in comprehensive urban transportation planning(Shin and Lee, 2017).

Other studies aim to innovate theoretical frameworks, emphasizing adaptive capacity in spatial planning(Kruse and Pütz, 2014), survival health(Zhang and Puterman, 2013), and climate change(Fu, 2020), along with discussing adaptive strategies and actions in transportation planning(Chow *et al.*, 2011), community governance(Zandvoort *et al.*, 2019), and disaster impact sectors(Nohrstedt *et al.*, 2022). Additionally, cutting-edge research focuses on adaptive planning application methods such as building adaptive models(Marsal-Llacuna and Fabregat-Gesa, 2016), algorithms(Chen and Yu, 2020), and scenario planning(Lempert *et al.*, 2006; Abou Jaoude, Mumm and Carlow, 2022).

In May 2022, the Chinese government issued the "National Climate Adaptation Strategy 2035," marking adaptive planning as a primary approach for China's climate issues in the new era. In China, adaptive planning is gradually becoming a focal point in academia, potentially offering more Chinese insights to global adaptive governance. Chinese researchers emphasize integrating adaptive processes with local planning characteristics, such as aligning with China's rural revitalization strategy(Yu, Qi and Gong, 2019) or integrating adaptation into unique Chinese planning policies like overall planning(Zhan and Sheng, 2014), and detailed planning(Yao, 2011).

Moreover, Chinese researchers excel in establishing adaptive systems within spatial planning contexts(Wu, 2021; Yue, Wei and Chen, 2021; Wang *et al.*, 2023), expanding to diverse planning scales. At smaller scales, discussions focus on the adaptability of parks(Li, Fan and Ma, 2018) and neighborhoods(Wang and Zang, 2018). At larger scales, exploration extends to area morphology(Chen, Sun and Li, 2021), green space systems(Xiao, Cao and Li, 2020), water space(Du and Tang, 2015), and cultural heritage sites(Song, Zhang and Xu, 2011), aligning with urban spatial adaptation. Additionally, research examines how adaptive methods can better serve population(Neumann *et al.*, 2015), public health(Leng and Li, 2021), and comprehensive transportation planning(Huang and Xu, 2019).

However, there are two shortcomings in the review analysis of adaptive planning: firstly, most reviews focus on climate change, lacking attention to the essence of "adaptation." Secondly, as mentioned subjectively, most reviews are qualitative, making it challenging to effectively reveal domain hotspots, structures, and implementation effects.

Therefore, this study focuses on indigenous Chinese adaptive planning research and practices. The second part defines the conceptual connotations of the study, the third part delineates the research progress of Chinese adaptive planning, the fourth part proposes issues and corresponding action plans, the fifth part studies the effectiveness of action implementation, and the sixth part discusses the practical insights of Chinese experience on global adaptive planning. We hope that through adaptive research on China's multi-element, multi-scale urban-rural complex systems, we can provide relatively objective experiential references for global researchers in adaptive planning (Figure 1).

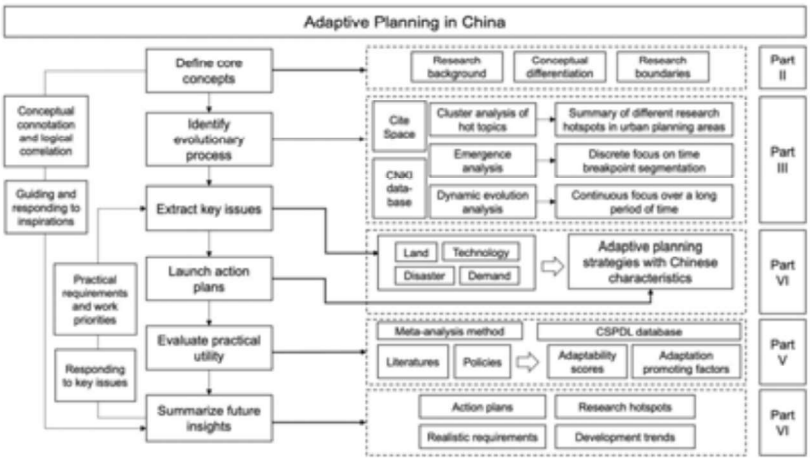


Fig.1 Research Framework

2. Concept: Understanding Adaptive Planning in China

A thorough understanding of the conceptual boundaries of adaptive planning is essential. "Adaptation" generally refers to continuous change and achieving balance with the environment.

This study considers multidimensional urban research and defines adaptive planning as "a proactive and dynamic approach to addressing uncertainties in urban development." Unlike traditional static and long-term planning, adaptive planning emphasizes pre-planning, rehearsal, and simulation for all scenarios, setting planning goals and specifics within shorter timeframes. During implementation, new events are continuously integrated, multi-stakeholder democratic decision-making is employed, and planning content is iteratively adjusted.

In the Chinese planning context, adaptivity has broader theoretical characteristics. First, adaptation is a tool for mitigating uncertainty. Chinese planning agencies conduct comprehensive surveys across transportation, social, and cultural domains, leveraging interdisciplinary perspectives to counter urban uncertainties and maximize planning benefits.

Secondly, adaptation is a dynamic process. Influenced by the Chinese philosophical concepts of "harmony between man and nature" and "non-action," Chinese adaptive planning

sets long-term development goals for each city and continuously monitors progress, aligning with the natural development patterns and effectively meeting the dynamic nature of planning.

Lastly, adaptation results in meeting individual needs. Guided by the "benevolent governance" philosophy of "Ren," Chinese planning emphasizes individual adaptation, addressing a wide range of ecological, cultural, transportation, social, disaster, and health needs. This approach is closely linked to the framework of Chinese planning disciplines.

3. Progress: Summarizing the Research Trajectory of Adaptive Planning in China by Knowledge Graphs

3.1 Methodology and Data Source

This study utilizes CiteSpace, a software developed by Professor Chaomei Chen, for scientometric and visualization analysis of Chinese literature. The software uses nodes, links, and colors to visualize the frequency, connection strength, and time intervals of literature, alongside keyword clustering analysis, burst detection, and dynamic evolution analysis.

Data is sourced from the China National Knowledge Infrastructure (CNKI) database, covering the past 20 years (2004-2024). After filtering the search results, 267 Chinese articles were selected for analysis.

3.2 Results

3.2.1 Analysis of Hotspot Keyword Clustering

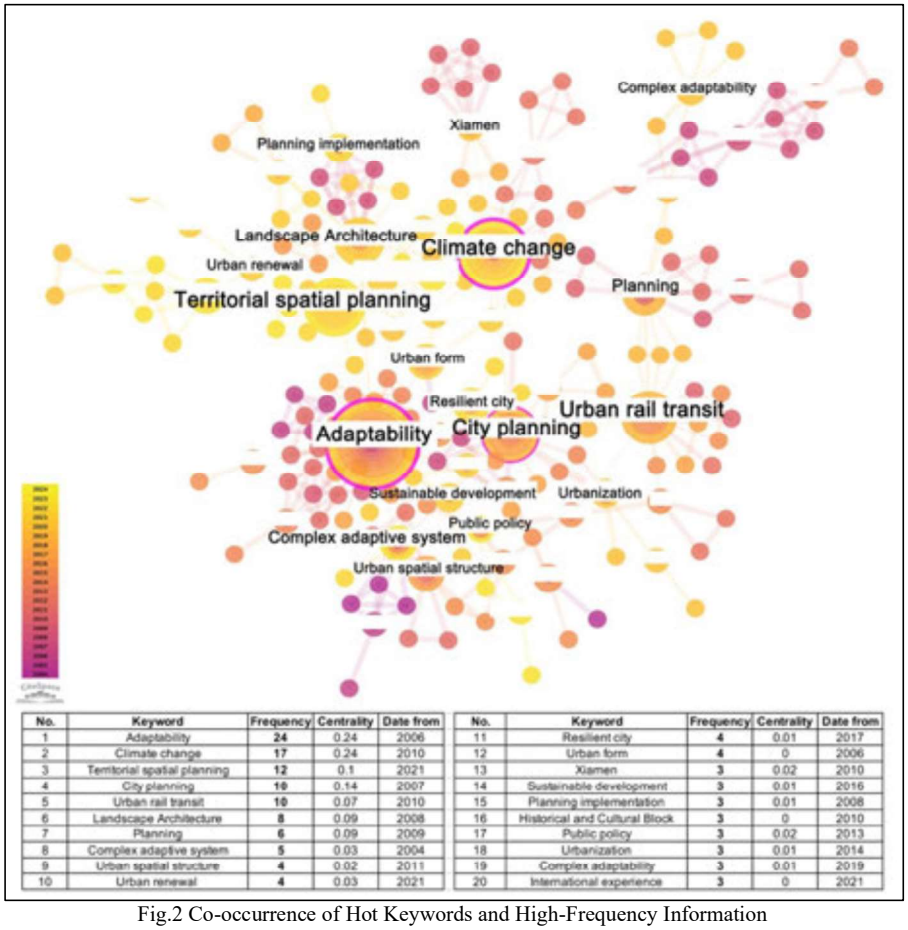
Over the past 20 years, the most frequent keywords in China have formed three major clusters: "adaptation" + "urban planning," "climate change" + "territorial spatial planning" + "landscape architecture," and "urban rail transit" + "planning" (Figure 2). Adaptive methods have increasingly dominated planning theory and practice.

On the theoretical level, research has focused on the origins of complex adaptive planning(Sun *et al.*, 2016) and sustainability(Ahern, 2011), ecological civilization(Du, He and Bao, 2018), resilient cities, and improving living environments(Cai and Wen, 2017; Chen and Li, 2023).

Practically, studies have examined the adaptability of master planning(Zhan and Sheng, 2014), regulatory planning(Yao, 2011), and the evaluation of planning implementation(Tang *et al.*, 2021). Territorial spatial planning(Wu, 2021; Yue, Wei and Chen, 2021; Wang *et al.*, 2023), urban spatial structure and morphology(Chen, Sun and Li, 2021), along with urban renewal(Li and Zhao, 2021) and old neighborhood renovation(Zhang *et al.*, 2023; Zhao and Liu, 2023) have also been explored.

Additionally, research has focused on international experiences in adaptive planning(Jiang, Yuan and Yu, 2021), health risks(Zhou, Wang and Wang, 2021; Chen, Wu and Lai, 2023), public policy and governance models(Qin, 2022), as well as rural and urban landscapes(Li, Fan and Ma, 2018; Ding and Ji, 2020) and transportation systems(Huang and Xu, 2019; Cui and Liu, 2023).

The focus of Chinese adaptive planning over the past 20 years has been closely linked to the development of traditional planning modes, evolving to address subcategories such as "spatial morphology, landscape green spaces, rail transit, and planning implementation" in response to the requirements of territorial spatial planning. However, the extensive knowledge network covered by these research clusters still requires theoretical and methodological innovations driven by "cross-disciplinary integration" keywords.



No.	Keyword	Frequency	Centrality	Date from
1	Adaptability	24	0.24	2006
2	Climate change	17	0.24	2010
3	Territorial spatial planning	12	0.1	2021
4	City planning	10	0.14	2007
5	Urban rail transit	10	0.07	2010
6	Landscape Architecture	8	0.09	2008
7	Planning	6	0.09	2009
8	Complex adaptive system	5	0.03	2004
9	Urban spatial structure	4	0.02	2011
10	Urban renewal	4	0.03	2021

No.	Keyword	Frequency	Centrality	Date from
11	Resilient city	4	0.01	2017
12	Urban form	4	0	2006
13	Xiamen	3	0.02	2010
14	Sustainable development	3	0.01	2016
15	Planning implementation	3	0.01	2008
16	Historical and Cultural Block	3	0	2010
17	Public policy	3	0.02	2013
18	Urbanization	3	0.01	2014
19	Complex adaptability	3	0.01	2019
20	International experience	3	0	2021

Fig.2 Co-occurrence of Hot Keywords and High-Frequency Information

3.2.2 Analysis of Emerging Hot Keywords

The strongest keyword emerging in China over the past 20 years is "territorial spatial planning," which has been emerging since 2021 (Figure 3). In May 2019, the Chinese government specified the establishment of a territorial spatial planning system and supervision implementation, achieving "integrated multiple plans into one." Provinces across the country have successively launched the compilation of 2021-2035 national spatial plans, coinciding with the starting period of related research emergence.

"Territorial spatial planning" also dominates with an emergence intensity coefficient of 5.73, becoming a recent research hotspot alongside topics like transportation development(Huang and Xu, 2019; Cui and Liu, 2023) and spatial renewal(Li and Zhao, 2021). Keywords such as "landscape architecture" and "urban planning" also reflect the characteristic of adaptive planning serving related disciplinary studies.

The emergence of "urban spatial structure" lasted for six years from 2011 to 2017, experiencing extensive, large-scale, and gray construction processes. China's urbanization construction focuses on urban spatial form structure(Wang and Zang, 2018; Yan *et al.*, 2018; Chen, Sun and Li, 2021), making refined adaptive adjustments and becoming a topic of sustained attention in recent years. Keywords like "urban renewal"(Li and Zhao, 2021), "urban governance"(Gu, Wu and Dai, 2021; Qin, 2022), and "rural revitalization"(Yu, Qi and Gong, 2019) had the latest starting time for emergence, reflecting recent research priorities in Chinese adaptive planning.

China's cities are gradually entering an era of stock urban renewal, requiring attention to urban-rural integration, ecological protection, industrial economy, and other diverse planning entities for flexible governance adjustments. It is evident that China's adaptive planning has gradually shifted its focus from climate change and disaster management to specific urban issues and adaptive implementation in recent years, providing a significant inspiration for international planning research.

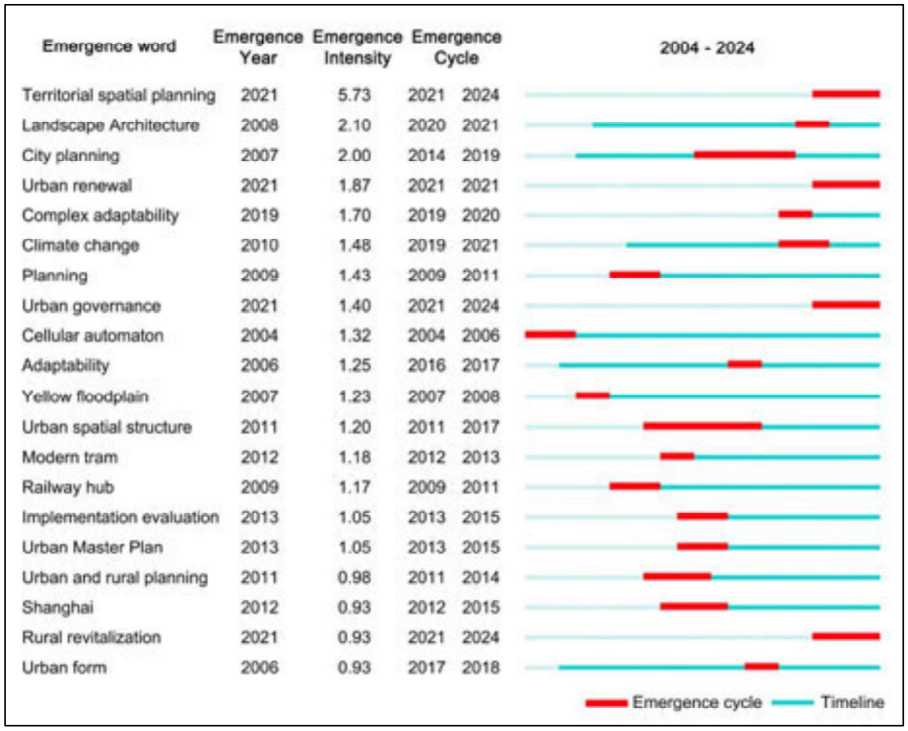


Fig.3 Emergence of Hot Keywords

3.2.3 Dynamic Evolution Analysis of Hot Keywords

Over the past 20 years, the hot keywords in China's adaptive planning have formed multiple generalized clusters such as climate change, urban rail transit, and spatial structure, indicating a dynamic evolution in three stages (Figure 4, Figure 5).

From 2004 to 2010 was the initial exploration period of China's adaptive planning, with relatively dispersed research content focusing on planning simulation, compilation, and multi-element adaptive planning involving urban form, water systems, and hub facilities.

From 2010 to 2020 marked the integration period of China's adaptive planning with climate change response. As global climate change issues unfolded, Chinese researchers actively engaged in climate adaptation as the main theme, exploring multi-element adaptive planning including public transportation, urban form, open space, cultural heritage, and public participation control.

Chinese literature during this period tended to discuss sustainable slowing and adaptation in the urbanization evolution process of the living environment and the dialectical relationship between planning development and protection.

After 2020, China entered a development phase where adaptive planning was incorporated into spatial planning, reflecting the era characteristics of Chinese planning. Based on territorial spatial planning, related research conducted adaptive governance studies on participatory planning, supply-demand optimization, public service facilities and space disaster reduction, urban renewal, etc., implementing spatial planning adaptation requirements of "comprehensive, all-element" and "step-by-step conduction."

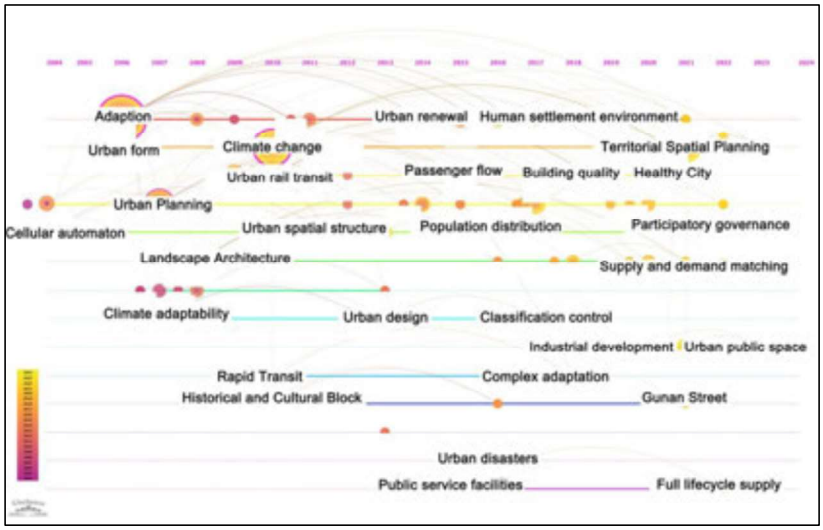


Fig.4 Timeline of Hot Keywords

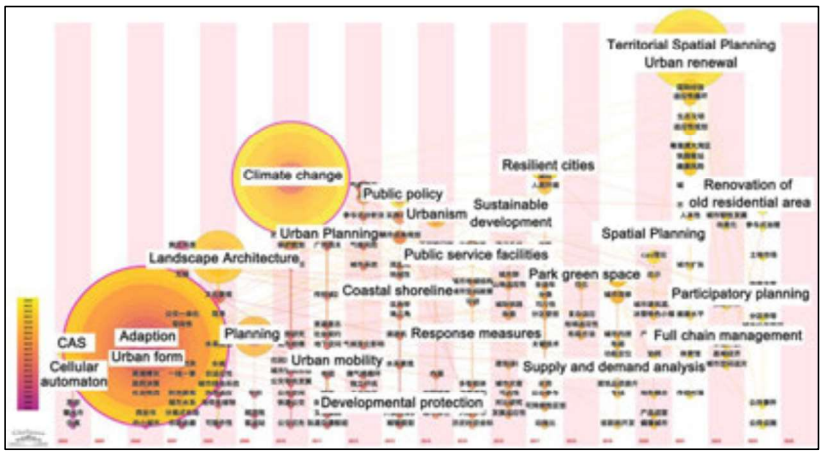


Fig.5 Time Zone of Hot Keywords

4. Issues and Actions: Addressing Adaptive Planning Challenges with Chinese Approaches

4.1 Key Issues in the Transformation of Urban Adaptive Planning in China

The concepts of urban planning in China are undergoing a transformation due to adjustments in national government structures and the introduction of territorial spatial planning policies. Based on a review of the past 20 years of research on adaptive planning in China, several key issues in this transformation have been identified.

On the research front, planning theory lags behind practice. China aims to integrate national strategic policies with theoretical and practical applications to enhance effectiveness. The efficient functioning of state machinery relies on the execution advantages of various administrative levels, necessitating that adaptive planning actions spatially respond to strategic directives.

Spatial planning must adapt to the processes and outcomes of top-level strategies proposed by the Chinese government, such as "ecological civilization," "a community with a shared future for mankind," "carbon peaking and carbon neutrality goals," and "a country with strong transportation network."

In practice, planning has yet to robustly address urban uncertainties. China is designing adaptive toolkits for different scales, adopting spatially adaptive resource management actions to handle urban nonlinear changes. For instance, in the later stages of urbanization, new technologies like autonomous driving and artificial intelligence are leveraged to meet diverse individual needs.

Guided by these key issues, China is exploring an action path for adaptive planning, leveraging its institutional and execution advantages to facilitate a shift in thinking.

4.2 Adaptive Planning Actions Addressing Key Issues

The most prominent feature of China's adaptive planning, and its most effective action plan, is the integration of territorial spatial planning with multi-scale and multi-objective adaptability.

At the national and regional levels, strategic planning is spatially implemented to manage gradual or drastic changes in urban development, ensuring controlled and positive development in the medium to long term. At the city and community levels, multi-objective comprehensive adaptation and the realization of citizen will be emphasized, ensuring iterative adjustments throughout the lifecycle of planning, akin to "moving targets" for stationary objectives.

This process is often driven by specialized administrative bodies, benefiting from top-down administrative execution and long-term construction. An efficient policy implementation system ensures that national intentions are accurately reflected spatially, responding to top-level strategic designs. This facilitates effective linkage and practical implementation of adaptive planning at various scales in China.

Additionally, China's adaptive planning employs cross-disciplinary research methods and legally integrated planning processes, providing multi-domain feasibility and responding to the comprehensive theoretical core of China's adaptability.

Collaboration between experts from academia and industry has yielded various contingency plans for different urban types and emergencies, such as shrinkage planning and refined governance for high-density cities, smart growth and urban-rural integration for developing cities, and the use of emerging technologies for planning autonomous driving lanes, simulating residential patterns, or identifying ecological risks.

Moreover, community participatory governance effectively meets individual needs. China has implemented a legally recognized and protected system where experts with planning backgrounds serve as responsible planners for specific urban communities. This ensures that different urban areas can genuinely adapt to local characteristics during development and that higher-level administrative directives are implemented more normatively and efficiently. Additional examples include adaptive spatial planning strategies that cater to children, the elderly, and people with disabilities, as well as promoting pedestrian and cycling-friendly environments.

5. Effectiveness: Quantifying the Implementation Outcomes of Adaptive Planning in China Using Meta-Analysis

5.1 Methodology and Data Sources

Firstly, we conducted a comprehensive literature review of Chinese adaptive planning, selecting cases through abstract and full-text analyses to finalize our dataset.

Given China's political system, many adaptive planning implementations are enforced through government policies, either mandatorily or non-mandatorily. Consequently, we also collected relevant policies and administrative announcements from the State Council Policy Document Library, the official repository designated by the Central People's Government of the People's Republic of China.

The rigorous nature of official documents resulted in a limited number of relevant records from a single search. Therefore, we broadened our data collection scope to include documents related to adaptive planning in areas such as climate and environmental protection, social equity and inclusion, disaster resilience, transportation and infrastructure, public health, and urban preservation and renewal.

The criteria and process for selecting literature and policies are illustrated in Figure 6.

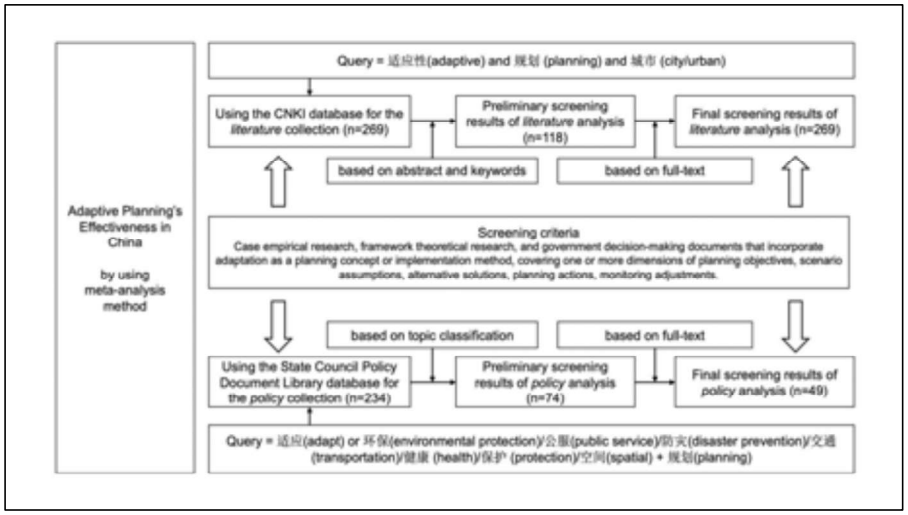


Fig.6 Selection Criteria for Meta-analysis Records

Next, we adapted a methodology from similar studies by Shirin Malekpour and Jens Newig (2020). Drawing from literature reviews by Jeuken et al. (2015), Quay (2010), and Walker et al. (2013), and tailored to China's context, we adopted evaluation dimensions including goals, scenarios, plans, actions, and monitoring. These dimensions were employed in a meta-analysis to assess and statistically evaluate the collected records. The formula used is as follows:

$$U = \sum_{k=1}^{N} S_k$$

$$S_k = \sum_{i=1}^{n} W_i * F_i$$

Where:

U represents the total adaptability score for all records.

N is the number of collected records.

S_k represents the total adaptability score for the k^{th} case, $S_k = \{0,0.5,1,1.5,2,2.5,3,3.5,4,4.5,5\}$.

n is the number of evaluation factors, which in this study is 5.

W_i is the weight of the i^{th} evaluation factor, which is set to 1 based on relevant literature (Shirin Malekpour and Jens Newig).

$F_i$is the adaptability score of the i^{th} evaluation factor, $F_i = \{0,0.5,1\}$.

The specific meanings and scoring standards are detailed in Table 1.

Tab.1 Definition and scoring criteria of evaluation factors

Evaluation factor	**Code**	**Definition**	**Score**		
			0	**0.5**	**1**
Planning objectives	F_1	Expectations for the outcomes of adaptive planning should include both quantifiable and non-quantifiable results.	Not any Planning objectives.	Goals may be vaguely defined or not easily quantifiable.	A list of clear and quantifiable objectives has been established.
Scenario assumptions	F_2	Various future planning scenarios and their potential outcomes should be hypothesized.	Not any Scenario assumptions.	One or two planning scenarios or hypotheses in different application areas have been proposed.	Three or more planning scenarios or hypotheses across different application areas have been proposed.
Alternative solutions	F_3	Multiple flexible planning actions should be proposed, with at least one plan adopted at each planning stage.	Not any Alternative solutions.	One or two alternative plans have been suggested.	Three or more alternative plans or phased implementations have been suggested.
Planning actions	F_4	There should be a conceptual or framework explanation for achieving the goals of adaptive planning, accompanied by concrete actions.	Not any Planning actions.	Conceptual or framework guidance for planning assumptions and alternative plans has been provided, but no concrete actions have been taken yet.	Clear and quantifiable action plans for the planning assumptions and alternatives have been provided, or concrete actions have already been taken based on existing plans.
Monitoring and adjustment	F_5	Continuous monitoring of any critical changes is essential, with proactive measures taken when necessary.	Not any Monitoring and adjustment.	Conceptual or framework methods for future monitoring and adjustments have been proposed, but no monitoring	Clear monitoring and adjustment goals have been established for existing plans, or ongoing monitoring and dynamic adjustments are being conducted.

				actions have been implemented yet.	

Finally, based on the attributes of the Promoting Factors in each record, we calculated the total score for all Promoting Factors from the evaluation results. This analysis identified the most critical driving factors for the implementation of adaptive planning, which can provide valuable governance insights for future research and practice in adaptive planning in China. The formula is as follows:

$$P_j = \sum_{k=1}^{N} S_k * \frac{1}{T_k}$$

Where:

P_j represents the adaptive score of the j^{th} Promoting Factor.

T_k represents the total number of adaptive Promoting Factors summarized from the k^{th} record.

N, k, and S_k have the same meanings as previously defined.

5.2 Results

5.2.1 Overall adaptability

Based on the aforementioned evaluation criteria, the overall status of completed or ongoing adaptive planning cases in China is relatively favorable, with an overall adaptability score of 2.32. Specifically, for individual evaluation factors with a total score of 1 point, these cases performed well in Planning Objectives, Planning Actions, and Scenario Assumptions, with average scores of 0.68, 0.60, and 0.61, respectively. However, there is room for improvement in Monitoring and Adjustment and Alternative Solutions, with average scores of 0.25 and 0.17, respectively (Figure 7).

In the various fields of adaptive planning in China, the highest number of records, 64, is in urban and rural planning and construction. Transportation and climate fields have 13 and 11 records, respectively, while other fields have fewer than 10 records. The average adaptability scores across different fields are relatively high. Notably, the disaster and climate fields achieved impressive average scores of 2.63 and 2.59, respectively (Figure 8).

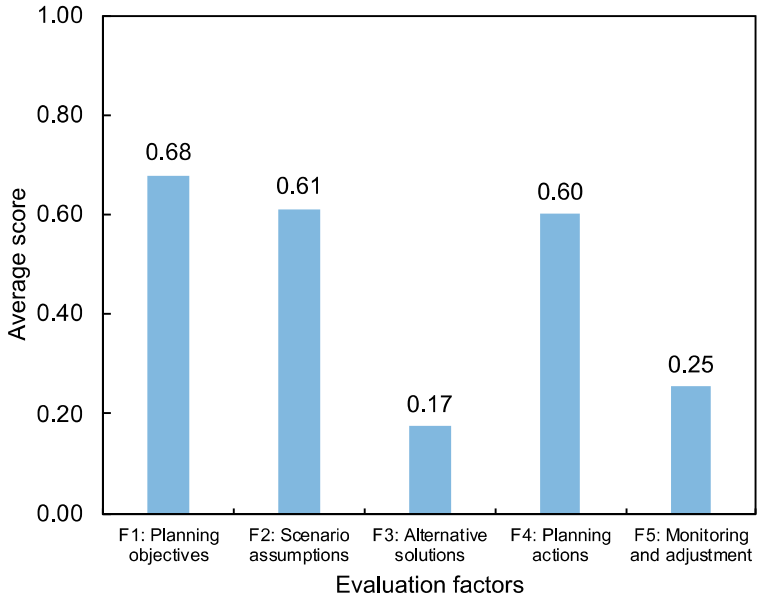


Fig.7 Average Adaptability Scores under Five Evaluation Factors

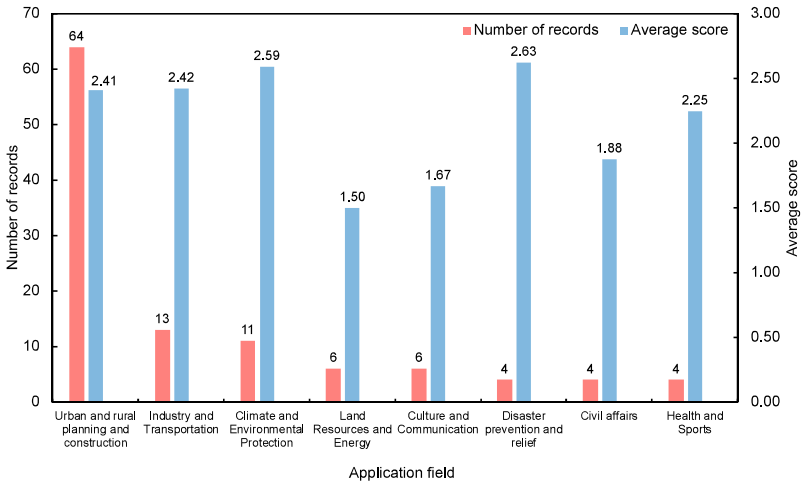


Fig.8 Number and Scores of Adaptive Planning Records in Different Fields

5.2.2 Promoting Factors of Adaptive Planning

We also identified ten key Promoting Factors for the adaptive planning process based on the content of the selected records (Figure 9). It is evident that top-down administrative orders

and interdisciplinary research are the most effective Promoting Factors, with 59 and 49 records respectively, and average scores of 0.41 and 0.36. Continued efforts are needed to promote community participation and public support, as well as investment activities involving related enterprises, as these factors have relatively low numbers of studies and average scores. According to the t-test results, administrative orders and community participation significantly impact the overall adaptability scores.

Regarding the effects of Promoting Factors on different evaluation factors (Figure 10), top-down administrative orders effectively promote the completion of planning objectives, actions, and subsequent monitoring, which is related to the Chinese government's public authority. Interdisciplinary research facilitates the use of scenario assumption methods, while cutting-edge technology supports the development of more alternative solutions, likely due to the academic community's application of theory and methods to practice. Additionally, interdisciplinary research and theoretical expansion play critical roles in meeting planning objectives and achieving overall adaptability results.

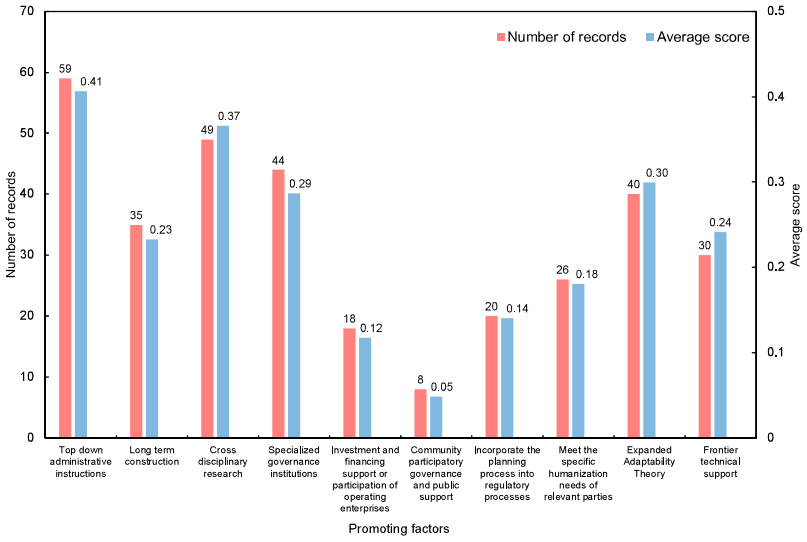


Fig.9 Number and Scores of Promoting Factors in Adaptive Planning Records

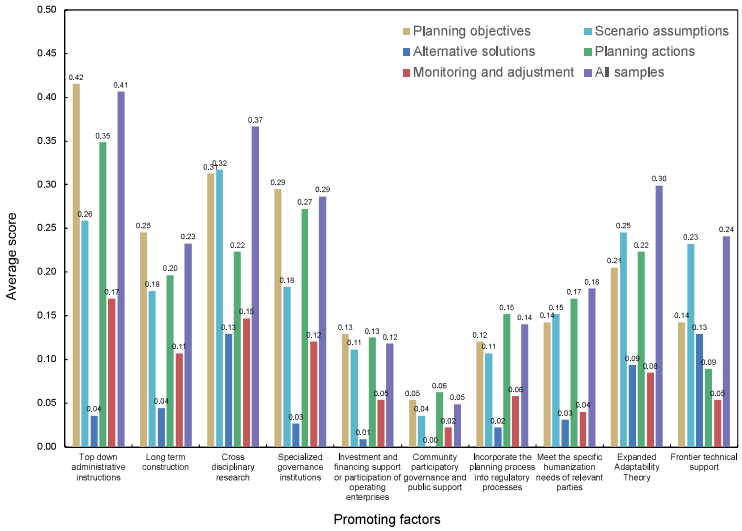


Fig.10 Scores for Each Factor for Promoting Factors in Adaptive Planning Records

6. Reflection: What Can We Learn from China's Adaptive Planning?

6.1 Insights from China's Adaptive Planning Research and Practice

Over the past 20 years, three major research focuses in China's adaptive planning can provide valuable references for the international community.

Firstly, the "timeliness" of adaptation is crucial. Addressing climate change and technological advancements remains a continuous priority for urban adaptability in China. Global climate issues significantly impact international politics and economics, while big data and artificial intelligence can effectively solve complex urban models. Future global adaptive planning should focus on strategies for various types of disasters, regions, and urban computing methods.

Secondly, the "people-centered" nature of adaptation is emphasized. Multi-disciplinary and cross-sectoral approaches that cater to individual needs are particularly important. China's adaptive planning research includes perspectives from culture, communication, industry, transportation, and health, all aiming to meet diverse human needs.

The adaptation of the built environment through spatial layout and policy control effectively integrates rational and emotional decision-making to comprehensively meet these needs. Future global adaptive planning should prioritize individual-centric values, considering citizens' primary needs concerning the environment and health.

Lastly, the "authoritativeness" of adaptation stands out. China's adaptive planning research highlights the characteristics of its political system, effectively utilizing consistent governmental power while considering citizen opinions and community participation. The government rigorously delineates specialized departments for natural resources, housing, and

transportation, which coordinate horizontally under the State Council's unified leadership to issue adaptive planning policies. These policies are directly and efficiently transmitted vertically to subordinate city departments and strictly adhered to. This long-term adaptive planning framework ensures effective future responses.

On one hand, city departments have detailed divisions of labor to collaboratively produce adaptation outcomes in various fields. On the other hand, the procedural basis of this process is legally grounded, ensuring implementation effectiveness. China's adaptive planning leverages these advantages at the macro level, with chief urban planners driving territorial spatial planning, and at the micro level, with community responsibility planners ensuring thorough stakeholder participation and adaptation implementation. These institutional strengths and methods are valuable for international reference.

6.2 Current Requirements, Development Trends, and Adaptive Action Framework for Global Adaptive Planning

Currently, academic attention on adaptive planning is predominantly focused on climate change and disaster risk. The core requirement is to expand research directions and develop localized adaptation strategies with regional characteristics. For instance, China has recently diversified its research content around territorial spatial planning.

The academic community should pay more attention to urban transportation, supply-demand matching, community governance, tourism development, and ecological protection in the context of population mobility, economic development, and technological innovation, forming a comprehensive adaptive planning research network.

Moreover, a clear goal-oriented approach to address pressing national issues is essential for identifying effective adaptive planning pathways. Examples include flood management in the Netherlands, green building initiatives in Singapore, and improved transportation planning in London.

Additionally, supporting adaptive principles with spatial intelligence technology, formalizing participatory planning into legislation, and applying it to decision-making at all levels to meet human-centered needs like social equity and resident health is also crucial.

Therefore, this study attempts to outline future development trends in adaptive planning. There is a systematic integration trend in existing global climate adaptation planning research. Future efforts should establish a reusable response mechanism through cross-disciplinary collaboration.

There is a trend of theoretical expansion in adaptive planning, requiring a clearer definition of its broad and narrow cores according to national strategic needs, specifying its covered fields, and proposing dynamic action plans to meet specific field requirements, which necessitates strong political measures.

Finally, adaptive planning exhibits a trend of multi-dimensional integration, serving the public. Combining foundations from engineering, management, social sciences, and intelligent tools will create more comprehensive and scene-specific adaptive planning methods, focusing adaptation efforts on individual needs.

Based on these trends, we propose a theoretical framework to guide future governance actions in adaptive planning (Figure 11).

Fig.11 Governance Action Framework for Adaptive Planning

7. Conclusion and Discussion

Based on defining the essence of adaptive planning, this study retrospectively reviews the progress and implementation effectiveness of adaptive planning in China using knowledge graph analysis and meta-analysis methods. The research indicates that the theoretical and practical aspects of adaptive planning in China have seen substantial development over the past 20 years, categorized into stages of planning adaptation exploration, climate adaptation dominance, and spatial adaptation development. Research hotspots like "Territorial spatial planning" and "Urban Renewal" with Chinese characteristics have been explored.

Concurrently, administrative orders and interdisciplinary research are the primary driving factors of adaptive planning in China, demonstrating significant implementation effects across multiple sectors and administrative departments. Within China's spatial planning context, studies have gradually moved away from a singular focus on climate change adaptation, instead exploring more localized adaptive pathways, potentially providing insights and ideas for adaptive planning globally.

However, there are shortcomings in this study, such as incomplete literature and policy collection, and subjective dimensions and methods in meta-analysis evaluations. The literature and policies of adaptive planning in China exhibit distinct characteristics, and future research will optimize data and evaluation methods for more detailed discussions.

Through "no-regret" short-term planning and dynamic adjustments involving multiple stakeholders, adaptive planning serves as a methodological guide for planners in China, effectively addressing rapidly evolving urban issues. Spatial planning needs proactive adaptation to promote equitable resource allocation, infrastructure, and public services,

addressing urban population, land, transportation, and environmental issues while fostering urban-rural integration and economic development.

This process requires the participation of planners, government, and the public, as well as supportive policies and regulations concerning land use, environmental protection, and planning standards. It also necessitates promoting optimized resource allocation across administrative regions, harmonious development, and collective adaptation, embracing the future of urban-rural changes with dynamic, flexible, and forward-looking adaptive planning methods.

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