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Effectiveness of Chinese Regulatory Planning in Mitigating and Adapting to Climate Change: Comparative Analysis Based on Q Methodology

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Abstract: With cities considered the main source of carbon emissions, urban planning could mitigate and help adapt to climate change, given the allocation and regulation of public policies of urban spatial resources. China's regulatory planning remains the basis for building permission in the original urban and rural planning, and the new territorial spatial planning systems, determining the quality of urban plan implementation. Comprehensive regulatory plans effectively reduce carbon emissions. This study employs Q methodology to compare and analyze urban planners' and practitioners' perceptions of China's regulatory planning in climate change mitigation and adaptation. The findings show that while regulatory planning is key, potential deficiencies include the gaps between regulatory from master plans, capacity shortages of designations and indicators, and unequal rights and responsibilities of local governments. However, mandatory indicators in regulatory planning, especially "greening rate," "building density," "land use type," and "application of renewable energy technologies to the development of municipal infrastructure" could effectively mitigate climate change. "Greening rate" is the core indicator in regulatory planning since it provides empirical evidence for the "green space effect". This study indicates that local customization of combined regulation of greening rate and green spaces could help mitigate and help China adapt to climate change.

Keywords: regulatory planning; climate change; mitigation; adaptation; Q methodology

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1. Introduction

The global impact of climate change on humans and the ecosystem is tremendous. The COVID-19 pandemic, together with extreme weather, has caused heavy losses to global economy. It is more emergent than ever to promote global governance and initiate post-pandemic programs that may reshape economic development with greener and cleaner approaches. Cities are the main sources of carbon emissions, driven by population growth, expansion of built-up areas, increase in heat emissions, and urban underlying surface changes that impact the urban climate [1,2]. Urban planning, as a public policy, may allocate and regulate spatial resources in urban areas and play a vital role in climate change mitigation and adaptation. An increasing number of municipalities are taking into consideration climate change during urban planning [3]. According to the levels of planning, climate change mitigation and adaptation in urban planning can be categorized into two types: the development strategy of balancing economic growth and green and low-carbon development, which could reflect in the practice of macroeconomic governance, and the technical regulation in urban plans that could achieve the goals of efficient energy use and emission reduction. The flexible use of planning indicators and professional designations in detailed plans may be key approaches to climate change mitigation and adaptation.

Global climate change has a significant and sensitive impact on China. In policy-making, China's national policies actively focus on mitigating climate change. In September 2020, China announced the national goal of "carbon peak by 2030, carbon neutral by 2060" to the world for the first time at the UN General Assembly. Emission reduction and low-carbon development have become important themes in China's national and environmental governance. In practice, the goal of carbon emission reduction has been integrated into the performance assessment of leading local cadres, which serves as a basis for future appointments and promotions. Target responsibility systems have been developed and applied to performance assessment, focusing on the achievement of carbon emission reduction goals.

China's regulatory planning was, is, and will remain the main basis for building permission in the original urban and rural planning system, and the new territorial spatial planning system, which directly determines the quality of implementation of urban plans. Therefore, whether the development of regulatory plans could effectively achieve the goals of carbon emission reduction would be of great significance for China to mitigate and adapt to the impact of climate change. However, various designations and indicators in regulatory planning have different adaptabilities and functions. The main research questions are as follows: What are the adaptabilities of the respective designations and indicators in climate change mitigation and adaptation at the city scale? How can these designations and indicators be appropriately applied to regulate urban development, thus achieving the goals of climate change mitigation and adaptation at the city scale?

2. Literature Review

Mitigation and adaptation are the two main solutions to global climate change. Reducing greenhouse gas emissions is the initial approach to mitigating climate change. Currently, climate change mitigation and adaptation actions are being implemented at the international, national, and local levels [4]. At the international level, various organizations have formulated and issued relevant plans to steer the strategic direction of global society in climate change mitigation and adaptation. For instance, the European Union (EU) has issued green and white papers that serve as the strategic standards for member-states to climate-change mitigation and adaptation [5]. Finland, a member of the Organization for Economic Cooperation and Development, first promulgated a national strategy for climate change adaptation in 2005. Other EU member-states have also developed strategies for climate change adaptation [6]. At the national level, there are certain differences in the measures of climate change adaptation in developed and developing countries. The actions of climate change adaptation in medium-and low-income countries are mainly short-term passive behaviors of non-governmental organizations, while in high-income countries, public agencies usually implement long-term planned actions to adapt to climate change [7]. However, even in different regions of the same country, there are disparities in the natural environment and socio-economic conditions. The formulation and implementation of adaptation plans at the local level can more effectively adapt to climate change [8].

Urbanization is the main factor affecting climate change [9]. With the agglomeration of population and industries, cities have become the main source of carbon dioxide emissions. Urban design impacts urban microclimates [10]. The frequency of extremely high temperatures and heavy precipitation in cities is increasing [11]. Urban planning is an important basis for the development of urban spatial forms [12]. Additional attention should be paid to urban planning's important role in mitigating and adapting to climate change [13,14]. However, existing studies show that only a few cities, such as New York, Paris, and London, have taken climate change into consideration in their master plans, while the majority of cities such as Beijing and Moscow still lack the integration of climate change concerns into relevant master plans [15]. In addition, urban planners have paid limited attention to climate change issues [16]. In terms of the performance of urban plan implementations, the impact of urban master plan implementations on climate change mitigation tend to be insignificant and even negative, resulting in urban microclimate deterioration, growth of internal traffic volumes, and an increase in temperature [17,18]. However, the heat island effect has not been alleviated. For example, the implementation of the master plan of Seoul has moved the heat island effect from one city center to two others [19,20]. Therefore, in reviewing both planning visions and the performance of plan implementations, it is clear that there are deficiencies in urban planning to mitigate and adapt to climate change.

China's regulatory plans may directly regulate all urban development behaviors. Designations and indicators in regulatory plans reflect various spatial regulation measures for climate change mitigation and adaptation at the city level.

In classical regulatory planning, designations and indicators can be grouped into six categories: land use regulation, building development regulation, regulation of environmental capacities, urban design guidelines, regulation of facilities and infrastructure, and spatial regulation of activities. At present, climate change mitigation and adaptation in regulatory planning focus on the development of low-carbon and resilient cities. Regarding climate change mitigation, existing studies have found that compact land development mode [21], low urban population density, high degree of integration of urban spatial structure and traffic system [22], average building height, and plot ratio [23] have a certain impact on carbon emissions. The increase in urban greening rate, green roofs, and vertical greens can effectively change the micro-climate of cities and alleviate the effects of urban heat islands [24]. To explain, the greening rate is a basic indiacator which can reflect the urban greening level on a plot. It indicates what portion of the zone area is necessary to be kept as green spaces. The green spaces here include public green spaces, gardens, and attached green spaces. Roof gardens are normally not included. Firstly, urban green space can have a positive impact on the urban microclimate environment by slowing down the urban heat island effect. The higher the urban greening rate, the greater the impact; On the other hand, urban green space form and spatial layout also play an important role in coping with climate change [25]. Regarding climate change adaptation, urban morphology plays an important role in helping coastal cities adapt to rising sea levels [26]. The mass development of urban green infrastructure can enhance urban ecological adaptability and the ability to adapt to extreme climate events [27]. Resilient cities could also be developed by adjusting land use compactness, sustainable transportation mode, building density, and the use of renewable energies [28]. As a note, the building density indicates what portion of the zone area is permissible for building development. The high-density architectural form in the core area of the city will increase the surface temperature and change the urban microclimate environment [29]. Urban land use types define and designate certain functions and uses of zones in urban planning areas. The change of land nature leads to the deterioration of ecological environment and affects urban precipitation and temperature. At the same time, the conversion of land use types in China has accelerated the disappearance of grassland and forest land types, which is not conducive to the development of urban carbon emission reduction [30].

In accordance with the literature analysis above, it is clear that some designations and indicators in regulatory planning are able to adapt to climate change. These designations and indicators belong to the categories of land use regulation, building development regulation, and regulation of environmental capacities. There is still no study on climate change mitigation and adaptation in regulatory planning with consideration of all relevant designations and indicators. Moreover, existing research has discussed the functions of individual designations and indicators without sufficient analysis of the relative effectiveness among designations and indicators. Finally, policy goals of climate change mitigation and adaptation are not consistent [31]. For each set of goal (mitigation or adaptation), the effectiveness of designations and indicators in regulatory planning are not well differentiated. Therefore, this study systematically explores the effectiveness of regulatory planning in mitigating and adapting to climate change, as a new expedition to the land of development regulation.

3. Data and Methodology

This study compares and analyzes the effectiveness of regulatory planning in mitigating and adapting to climate change by applying the Q methodology. This methodology was first proposed by William Stephenson, and is a research method for analyzing personal perceptions with a small sample size [32]. It may combine the advantages of traditional quantitative and qualitative research and provide a qualitative approach to explore the subjective structure of human beings based on statistical measures.

The formation of the Q set comprehensively reflects the opinions of existing literature and interviewees [33]. Based on a survey of selected key respondents with interviews and questionnaires, as well as the representative opinions in the relevant literature, according to the operation principles of quantity control, readability, and typicality, overall, 32 Q statements were chosen as the final Q set for this study. See Table 1.

Table 1. Presentation of the Q set.

No.	Content of Q Set
1	Regulatory planning plays a positive role in urban emission reduction and climate disaster mitigation [34]
2	Low-carbon development and ecological preservation oriented regulatory planning is still limited for the adaptation to climate change
3	Regulatory planning can effectively mitigate the negative impact of extreme weather events (such as heat wave, flood, and heat island effect)
4	The current regulatory planning has many shortcomings in adapting to climate change
5	In specific regional climate environments, mitigation and adaptation goals of regulatory planning may conflict with each other
6	On the macro scale, the fundamental goals of climate change mitigation and adaptation in regulatory planning are identical [35]
7	Local governments may apply regulatory planning as a policy tool to their climate change adaptation and mitigation programs
8	Regulation of compact land use and population size may contribute to climate change mitigation
9	Regulation of land use type and compatibility could positively realize the intensive use of land and reduce carbon emissions [36]
10	Regulation of plot ratio could mitigate climate change mainly by improving land use and development intensity [37]
11	Regulation of building density could mitigate climate change mainly by improving land use and development intensity
12	Green and open spaces are important components of urban spaces, which are of great significance to effectively mitigate climate change [38]
13	Regulation of building height could improve the urban microclimate, while regulation of building interval could meet the requirements of sunshine and ventilation
14	Regulatory planning shall designate public facilities and infrastructure for green traffic with proper locations of entrances, exits, and parking lots [39]
15	Energy saving, emission reducing new energies and technologies shall be applied to municipal infrastructure such as power supply and heating [40]
16	Scientific planning of waste disposal such as waste sorting could mitigate negative environmental impacts, save energy, and reduce emissions
17	The mandatory indicators in regulatory planning could be more efficient and effective in mitigating climate change in comparison to the guiding indicators
18	Increase of the greening rate could increase the carbon sink, and therefore alleviate the heat island effect [41]
19	Regulation of building development could meet the requirements of building energy saving, disaster prevention, ventilation, and therefore alleviate the heat island effect and improve the urban environment

Table 1. *Conts.*

No.	Content of Q Set
20	Water supply and drainage engineering in municipal infrastructure planning plays an important role in adapting to extreme weather such as drought and rainstorm [42]
21	Scientific adjustment of public transport, slow traffic and static traffic facilities is helpful to adapt to the extreme weather [43]
22	Regulation of green lines (control of green spaces) and blue lines (control of water bodies) could effectively protect the ecological environment and improve the adaptability of urban climate [44]
23	Urban design guidelines focus on the micro level spatial regulation, which could achieve the goal of urban thermal climate improvement
24	There are limited indicators to adapt to climate change in regulatory planning, among which the guiding indicators are more effective in adapting to the extreme weather [31]
25	Lack of regulation of underground spatial uses in regulatory planning is a problem due to the important role of underground spatial use in the intensive use of land [45]
26	There is a lack of localized regulation for different regions in regulatory planning, such as coastal areas or historical blocks
27	Regulation indicators in regulatory planning are not targeting and could not achieve the goals of climate change mitigation and adaptation
28	More relevant regulation indicators could be introduced to regulatory planning, such as utilization rate of reclaimed water and permeable ground rate
29	In terms of urban design guidelines in regulatory planning, the positive role of the overall spatial pattern of built-up areas in improving the urban thermal environment has been ignored
30	Local governments should actively apply planning tools to mitigate climate change, avoiding the sole consideration of local interests and short-term interests [46]
31	Specific requirements related to climate change mitigation and adaptation in master plans should be implemented in regulatory plans
32	In regulatory planning, differences in applicability and function of the indicators in mitigating and adapting to climate change should not be ignored

The P set refers to the respondents of Q sorting who are as heterogeneous as possible and theoretically relevant to the research theme, also known as Q participants. In accordance with the professional and practical characteristics of this research theme, relevant experts and practitioners were chosen as Q participants. The heterogeneous requirement has been fulfilled by the wide geographical distribution and department diversity of the Q participants. The Q participants included experts from the China Academy of Urban Planning and Design, China Architectural Design Group, Beijing Institute of Urban Planning and Design, Guangdong Urban and Rural Planning and Design Institute, Guangxi Urban-Rural Planning and Design Institute, and Peking University. The practitioners of Q participants were from the municipalities of Beijing, Shijianzhuang, Jinan, Linyi, Taicang, Yinchuan, Lanzhou, and Shenzhen. The 36 Q participants completed the Q sorting, in which 25 samples were valid. The sample size was reasonable and met the research criteria [30].

Q sorting occurs when the individual participant ranks the Q statements into a Q grid. The Q grid used in this research applied a forced quasi-normal distribution with a common ±5 structure. A pre-set pattern grid with a scale was labeled "most important," "neutral," and "least important". The Q participants need to read the "condition of instructions" for Q sorting and sort the Q statements. See Table 2.

Table 2. 11 level Q sorting in a forced quasi-normal distribution.

Attitude	Least Important				Neutral			Most Important			
Number of Clustering Frequency	−5 (1)	−4 (2)	−3 (3)	−2 (3)	−1 (4)	0 (6)	1 (4)	2 (2)	3 (3)	4 (2)	5 (1)

4. Analysis and Interpretation

Principal component analysis (PCA) was applied to factor analysis. Table 3 lists the eigenvalues of the PCA and their cumulative percentages.

Table 3. Eigenvalues and cumulative percentages of principal component analysis.

No. of Sorts	Eigenvalues	As Percentages	Cumul. Percentages
1	7.3004	29.2016	29.2016
2	3.5209	14.0835	43.2851
3	2.4444	9.7776	53.0628
4	1.9519	7.8077	60.8704
5	1.616	6.4642	67.3346
6	1.2152	4.8607	72.1953
7	1.0936	4.3745	76.5698
8	0.981	3.9239	80.4938
9	0.809	3.2361	83.7299
10	0.7132	2.8527	86.5826
11	0.5769	2.3078	88.8904
12	0.5666	2.2664	91.1568
13	0.3956	1.5823	92.7391
14	0.3718	1.4872	94.2263
15	0.2931	1.1724	95.3987
16	0.2641	1.0563	96.455
17	0.2163	0.8653	97.3203
18	0.1866	0.7465	98.0668
19	0.1504	0.6016	98.6684
20	0.1327	0.5309	99.1993
21	0.0899	0.3594	99.5588
22	0.0562	0.2249	99.7836
23	0.0272	0.109	99.8926
24	0.0178	0.071	99.9637
25	0.0091	0.0363	100

According to the Kaise rule, it is significant only when the eigenvalue of a factor is greater than 1. Table 3 shows that only the first seven principal components have eigenvalues greater than 1, while that of the eighth principal component is 0.981, which is close to 1. Moreover, the cumulative percentages of the first eight principal components exceeded 80%. The gravel map in Figure 1 also shows that the eight principal components can be retained. Therefore, the first eight principal components were selected for factor rotation.

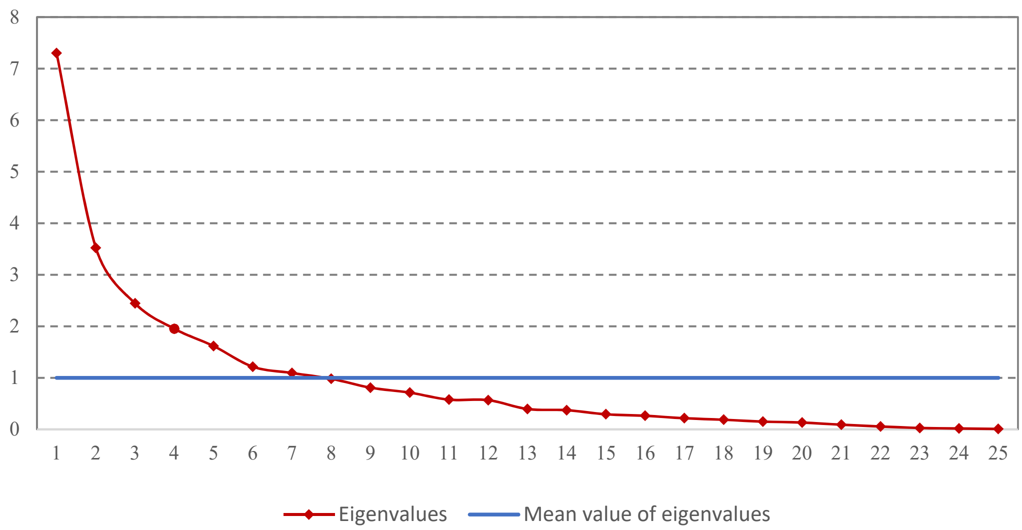

Figure 1. Gravel map of principal components.

Meanwhile, to improve the interpretability of each principal component and ensure a significant impact effect, the varimax rotation method was applied to factor rotation. Table 4 shows the number of sample records for each principal component as a result of factor rotation. It can be found that the number of sample records on the first, second, third, fourth, and eighth principal components were no less than 2. The number of sample records on the second principal component is 4, while the number of sample records on the F5, F6, and F7 principal components is only 1. In addition, the sample cumulative percentages of the F5, F6, and F7 principal components were relatively low. Therefore, according to the eigenvalues of the principal components and the number of sample records after factor rotation, the first four principal components were chosen for factor analysis.

Table 4. Sample records and cumulative percentages of the principal components.

Principal Component	F1	F2	F3	F4	F5	F6	F7	F8
Sample Records	2	4	2	2	1	1	1	2
Cumulative Percentages %	12	15	9	10	7	8	9	9

4.1. Factor Score

The scores of the Q statements were obtained by PCA and factor rotation (see Table 5), which reflect Q participants' different perceptions of the Q statements. The shaded parts in Table 5 represent the top three scores of the Q statements in the respective principal components. The numbers of principal components whose scores are sorted in the top three on each Q statement are marked in the last column. For example, "**" indicates that there are two principal components whose scores are sorted in the top three on this Q statement. Specifically, there are four principal components whose scores are sorted in the top three on statement Q12, while there are two principal components whose scores are sorted in the top three on statements Q8, Q9, Q18, Q27, and Q31. The Q participants generally believe that statement Q12 is very important, which indicates the vital role of the greening rate in climate change mitigation.

Figure 2 shows the arithmetic means of the Q statements on the first four principal components. The mean score of statement Q12 is the highest, followed by statements Q9 and Q18. The lowest mean scores are, in turn, statements Q24, Q6, and Q5.

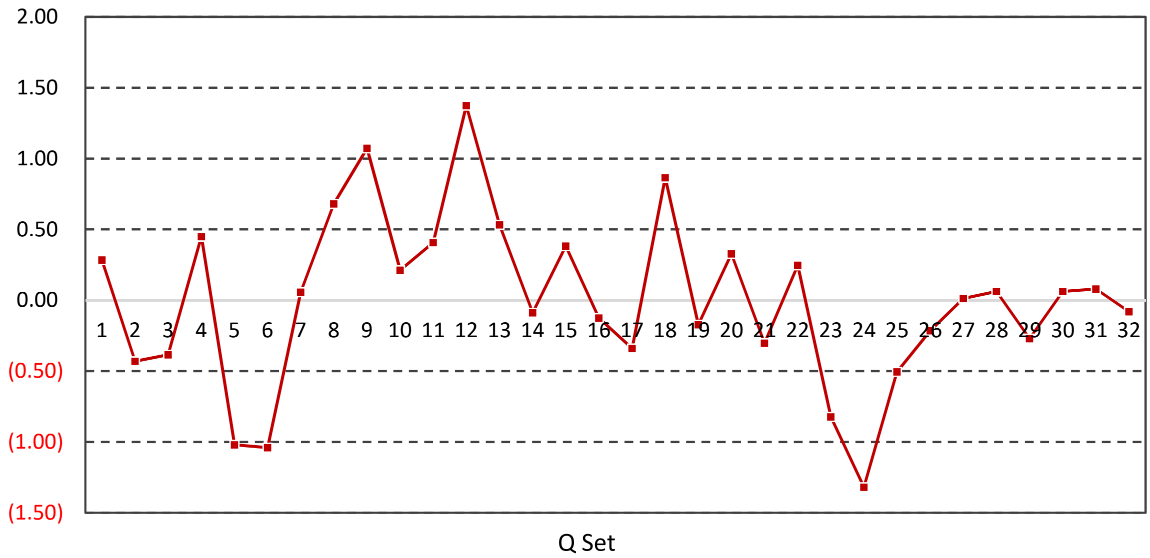

Figure 2. Arithmetic means of the Q statements.

The results clearly reveal the key role of the regulation of green spaces in mitigating and adapting to climate change, as well as uncertain goals in regulatory planning in response to climate change.

Table 5. Factor scores of the principal components.

No.	F1		F2		F3		F4		F5		F6		F7		F8		Remarks
	Score	Sort	Score	Sort	Score	Sort	Score	Sort	Score	Sort	Score	Sort	Score	Sort	Score	Sort	
1	0	16	1.35	5	−0.97	29	0.76	8	0	19	0.39	13	1.97	1	−1.39	30	*
2	0.3	15	0.49	9	−1.79	32	−0.72	25	0	19	0	19	−1.57	31	−0.49	24	
3	−1.54	31	−0.44	21	−1.58	30	2.02	1	0	19	−0.39	23	0.39	13	−0.33	21	*
4	1.99	1	0.24	14	−0.26	20	−0.17	16	1.18	6	0	19	−1.18	29	−0.2	19	*
5	−0.92	27	−1.18	28	−0.89	24	−1.09	29	−1.18	29	−0.79	26	−1.18	29	−1.25	29	
6	−0.92	27	−1.34	31	−1.6	31	−0.3	17	−0.79	26	−0.79	26	−0.79	26	−2.14	32	
7	−1.23	30	0.23	15	0.43	14	0.8	7	−0.79	26	0.39	13	−0.79	26	−2.01	31	
8	1.38	3	0.63	7	0.67	10	0.04	15	0.39	13	−1.97	32	1.57	3	−1.19	28	**
9	1.22	6	0.13	16	1.38	3	1.56	3	−1.97	32	−0.39	23	0.79	9	−0.89	27	**
10	0.45	13	0.56	8	0.69	9	−0.85	27	1.57	3	−0.39	23	0.39	13	−0.46	23	*
11	1.22	6	0.29	12	1.34	5	−1.22	31	0	19	0.39	13	0.39	13	1.32	3	*
12	1.37	4	1.01	6	1.56	2	1.56	3	1.97	1	0.79	9	1.18	6	1.52	1	****
13	−0.46	20	0.28	13	1.81	1	0.5	9	1.18	6	0.79	9	0.79	9	1.22	4	*
14	0.77	8	−1.25	30	0.5	12	−0.37	20	−1.57	31	1.18	6	0	19	1.09	7	
15	0.61	10	−0.87	25	1.36	4	0.43	11	0.39	13	1.57	3	0	19	1.09	7	*
16	0.46	12	−0.63	23	−0.63	22	0.3	12	0	19	1.57	3	−0.39	23	0.96	9	*
17	−1.07	28	−0.38	20	0.89	7	−0.8	26	0	19	0.79	9	0.79	9	−0.89	27	
18	0.76	9	0.36	10	0.65	11	1.69	2	1.57	3	−0.39	23	0	19	0	16	**
19	0.31	14	−0.99	26	0.45	13	−0.46	21	0.39	13	−0.79	26	0.39	13	0	16	
20	0.77	8	−0.15	18	−0.24	19	0.93	6	0.79	9	1.97	1	−0.39	23	−0.3	20	*
21	0.47	11	−1.25	29	−0.89	24	0.46	10	−1.57	31	0.39	13	−0.39	23	1.39	2	*
22	−0.6	21	0.11	17	0	15	1.48	5	1.18	6	0	19	1.18	6	1.02	8	
23	−0.77	25	−1.11	27	−0.91	26	−0.5	22	−0.39	23	−1.18	29	−0.79	26	−0.76	25	
24	−1.22	29	−1.94	32	−0.93	27	−1.19	30	−1.18	29	−1.57	31	−1.97	32	0.56	12	
25	−0.76	24	−0.69	24	−0.24	19	−0.33	19	−0.79	26	−1.18	29	−1.18	29	0.66	11	
26	−0.16	17	−0.49	22	−0.43	21	0.22	13	−0.39	23	0	19	−1.57	31	0.76	10	
27	1.53	2	1.75	2	−0.91	26	−2.32	32	0.39	13	1.18	6	−0.39	23	−0.43	22	**
28	−0.45	19	−0.18	19	0.71	8	0.17	14	0.79	9	1.18	6	0	19	0.16	13	
29	−0.61	23	0.34	11	−0.22	17	−0.59	24	−1.18	29	0	19	1.18	6	0.03	14	
30	−1.99	32	1.38	4	1.19	6	−0.33	19	−0.39	23	0	19	0	19	1.12	5	
31	−0.3	18	2.16	1	−0.95	28	−0.59	24	0.79	9	−1.57	31	1.57	3	−0.03	17	**
32	−0.61	23	1.57	3	−0.22	17	−1.06	28	−0.39	23	−1.18	29	0	19	−0.13	18	*

4.2. Factor Interpretation

The first four principal components were chosen for factor analysis and interpretation in accordance with the eigenvalues and cumulative percentages of the principal components. The scores of Q statements corresponding to each factor were ranked with positive cognitions (Q4 to Q6 statements with the highest scores) as the main content, and the Q statements with low scores as auxiliary interpretations.

It can be found that the four factors chosen may reflect four types of cognitive judgments: first, the overall judgment of the impact of regulatory planning (F1); second, the interpretation of the impact of regulatory planning (F2); third, the judgment of regulatory planning's role in climate change mitigation (F3); and fourth, the judgment of regulatory planning's role in climate change adaptation (F4). The classification of factor interpretation above (based on the statistical results) is consistent with the preset latitude of the concourse definition and building (based on the literature review).

4.2.1. Overall Judgment (F1) and Interpretation (F2) of the Impacts of Regulatory Planning

The results in Table 6 show that there are many deficiencies in the current regulatory planning for climate change adaptation (Q4), and the Q participants do not believe that regulatory planning has effectively achieved the goal of mitigating the negative impact of different extreme weather events (Q3). The main interpretations are as follows. (a) Regulatory plans should be consistent with relevant master plans (Q31). This indicates that the strategic deployment of macro-level planning is necessary for climate change mitigation and adaptation. (b) Specific indicators in regulatory planning are not well targeted at the goals of climate change mitigation and adaptation (Q27). Special attention should be paid to land use regulation (Q8) and the regulation of green spaces and open spaces (Q12). The application of each indicator in regulatory planning should consider the differences in the indicator applicability and function (Q32). (c) The externality and responsibilities of local governments in climate-change mitigation and adaptation. The Q participants believed that local governments would not reasonably apply regulatory plans as policy tools when formulating programs for climate change adaptation and mitigation (Q7). Climate change is an issue with spatial and temporal complexity and regional externalities. Local governments should avoid the sole consideration of local interests and actively apply planning tools to climate change mitigation and adaptation (Q30).

Table 6. Factor scores of the Q statements corresponding to Factors 1 and 2.

No.	Q Statements (F1)	Score
1	The current regulatory planning has many shortcomings in adapting to climate change (Q4)	1.991
2	Regulation indicators in regulatory planning are not targeting and could not achieve the goals of climate change mitigation and adaptation (Q27)	1.532
3	Regulation of compact land use and population size may contribute to climate change mitigation (Q8)	1.381
4	Green and open spaces are important components of urban spaces, which are of great significance to effectively mitigate climate change (Q12)	1.37
No.	**Q Statements (F2)**	**Score**
1	Specific requirements related to climate change mitigation and adaptation in master plans should be implemented in regulatory plans (Q31)	2.162
2	Regulation indicators in regulatory planning are not targeting and could not achieve the goals of climate change mitigation and adaptation (Q27)	1.755
3	In regulatory planning, differences in applicability and function of the indicators in mitigating and adapting to climate change should not be ignored (Q32)	1.574
4	Local governments should actively apply planning tools to mitigate climate change, avoiding the sole consideration of local interests and short-term interests (Q30)	1.377

4.2.2. Judgment of Regulatory Planning's Role in Climate Change Mitigation (F3)

The four Q statements with the highest scores corresponding to Factor 3 are all about the cognitive judgment of the relationship between regulatory planning and climate change mitigation. See Table 7. The results show that: (a) the regulation of building height and building interval would improve urban microclimate and meet the requirements of sunshine and ventilation (Q13). (b) The regulation of greening rate and building density may have a significant impact on climate change mitigation (Q12) (Q11). The regulation of green spaces and open spaces is an effective method for preserving the natural environment and ecological systems, while the regulation of building density manages to control the over-occupation of natural land by limiting the spatial scope of building behaviors. (c) The regulation of land use type and compatibility could improve the performance of intensive land use, and therefore reduce carbon emissions (Q9). (d) Indicators related to green innovation and development are of positive significance (Q15). The latest energy-saving and environment-friendly technologies should be applied to the development and renovation of municipal infrastructure. The results above focus on the designations and indicators of climate change mitigation, nearly all of which are mandatory designations and indicators.

Table 7. Factor scores of the Q statements corresponding to the Factors 3.

No.	Q Statements (F3)	Score
1	Regulation of building height could improve the urban microclimate, while regulation of building intervals could meet the requirements of sunshine and ventilation (Q13)	1.815
2	Green and open spaces are important components of urban spaces, which are of great significance to effectively mitigate climate change (Q12)	1.556
3	Regulation of land use type and compatibility could positively realize the intensive use of land and reduce carbon emissions (Q9)	1.382
4	Energy saving, emission reducing new energies and technologies shall be applied to municipal infrastructure such as power supply and heating (Q15)	1.361

4.2.3. Judgment of Regulatory Planning's Role in Climate Change Adaptation (F4)

The top six Q statements with the highest scores corresponding to Factor 4 ideally reflect the meaning of Factor 4 (See Table 8). In theory, regulatory planning is still an effective approach to mitigate the negative impact of extreme weather events (such as heat waves, floods, and heat island effects) (Q3). However, the results of factor 1 analysis show that the actual effect of this mitigation is not obvious. In addition to being a key tool in climate change mitigation, the greening rate is also a key indicator of climate change adaptation (Q12). While a higher greening rate could increase the carbon sink and alleviate the heat island effect (Q18), designations of green and blue lines could effectively regulate land uses of ecological spaces, in order to secure environmental protection and improve the adaptability of urban climate (Q22). In addition, well-developed and prepared municipal infrastructure could effectively adapt to extreme weather conditions, such as drought and rainstorms (Q20).

Table 8. Factor scores of the Q statements corresponding to the Factors 4.

No.	Q Statements (F4)	Score
1	Regulatory planning can effectively mitigate the negative impact of extreme weather events (such as heat wave, flood, and heat island effect) (Q3)	2.021
2	Increase of the greening rate could increase the carbon sink and therefore alleviate the heat island effect (Q18)	1.687
3	Regulation of land use type and compatibility could positively realize the intensive use of land and reduce carbon emissions (Q9)	1.558
4	Green and open spaces are important components of urban spaces, which are of great significance to effectively mitigate climate change (Q12)	1.558
5	Regulation of green lines (control of green spaces) and blue lines (control of water bodies) could effectively protect the ecological environment and improve the adaptability of urban climate (Q22)	1.48
6	Water supply and drainage engineering in municipal infrastructure planning plays an important role in adapting to extreme weather such as drought and rainstorm (Q20)	0.93

5. Conclusions and Recommendation

5.1. Conclusions

Through the analysis of experts' and practitioners' perceptions, the Q methodology application in this study provides a professional perspective of the effectiveness of regulatory planning in climate change mitigation and adaptation. The research findings reveal the details of the three main relationships existing between regulatory planning and climate change mitigation and adaptation.

The first relationship is the overall impact of regulatory planning on climate change mitigation, adaptation, and corresponding interpretation. Regulatory planning is considered a key approach to mitigate and help adapt to climate change, but it has many deficiencies. Possible reasons could be (a) The disconnection of regulatory plans from master plans. There have been sector plans for low-carbon development in China that have facilitated the recent development of pilot low-carbon cities. However, the goal of carbon and emission reduction in urban planning and the relevant collaborative logic between master plans and regulatory plans remain unclear. (b) Capacity shortages of designations and indicators in regulatory planning for climate change mitigation and adaptation. The capabilities of the existing designations and indicators cannot fully meet the regulatory requirements of carbon emissions and emission reduction. Adaptable and functional differences in the designations and indicators of climate change mitigation and adaptation have not been clearly defined. (c) Unequal rights and responsibilities of local governments in climate change mitigation and adaptation. Negative impacts and/or disasters caused by climate change may be concentrated in certain regions. Therefore, various regions may face different opportunities and risks. In this case, most of the responsible subjects and beneficiaries of climate change mitigation and adaptation were not identical. This externality of climate change could directly affect decision-making and the actions of local governments in various regions.

The second is the relationship between regulatory planning and climate-change mitigation. The indicators that may effectively mitigate climate change are the "greening rate," "building height," "building interval," "building density," "land use type," "land use compatibility," and "application of renewable energy technologies to the development of municipal infrastructure". The aforementioned indicators mentioned account for approximately a quarter of all indicators, and are all mandatory.

The third is the relationship between regulatory planning and climate change adaptation. Relevant indicators are the "greening rate" and "application of renewable energy technologies to the development of municipal infrastructure".

Regarding the effectiveness of regulatory planning in climate change mitigation and adaptation, the following characteristics can be summarized: First, mandatory designations and indicators are more effective in development regulation than guiding designations and indicators. Second, regulatory planning works mainly in climate-change mitigation with functions of carbon and emission reduction. Third, the greening rate is the core indicator in regulatory planning for climate change adaptation. The Q statements corresponding to the greening rate had the highest arithmetic mean scores. Meanwhile, these Q statements have priority rankings for all the factors. In factor interpretation, the greening rate, which serves as an important joint indicator for mitigating and adapting to climate change, can directly interpret capacity shortages of regulatory planning in climate change mitigation and adaptation corresponding to all the four factors.

The regulatory planning was working as the Chinese version of zoning code but with less legally binding power of regulation. However, the regulatory planning has survived the fundamental transition from the original urban and rural planning system to the new territorial spatial planning system. It was, is and will be the main basis for building permission nationwide. Meanwhile, since the territorial spatial planning is becoming one of the key policies tools of the Chinese central government, the regulatory planning, as an integral practical part of the territorial spatial planning system, would be playing a vital role in achieving China's goals of carbon emission reduction and carbon neutralization. In this case, the regulatory planning may be an indispensable policy tool in climate change mitigation and adaptation in comparison to its counterparts in other countries, and maybe more effective due to the continuously strengthened and centralized authority of China's territorial spatial planning.

5.2. Recommendation

This study provides three recommendations for regulatory planning for climate change mitigation and adaptation in practice.

First, it is imperative to apply effective technical approaches. In the formulation and modification of regulatory plans, relevant goals of climate change mitigation and adaptation in master plans and sector plans should be deliberately considered and implemented by mandatory designations and indicators in regulatory plans. Special attention should be paid to the formulation of greening rates and control lines of green spaces in order to establish concrete spatial boundaries of climate change mitigation and adaptation. The regulation of green spaces and open spaces is more rigid and effective than the that of the greening rate. Based on the core status of the greening rate in climate change mitigation and adaptation, the spatial regulation of green spaces and open spaces must work together with the regulation of the greening rate to preserve necessary green spaces in cities and directly increase the carbon sink. In contrast, other indicators such as land use type and building density would be more flexible and possibly changed by the discretion of local administrations. The carbon-oxygen balance-oriented combined regulation of the greening rate and green spaces could reduce rooms of administrative discretion. The scientific and reasonable local customization of the combined regulation of the greening rate and green spaces would be a vital approach to effectively mitigate and adapt to climate change in China in the future [38].

Moreover, local obligations of carbon emission reduction should be made compulsory. The obligations could be established by applying the target responsibility system to the performance assessments of local decision makers and public servants.

Finally, it is also important to upgrade existing designations and indicators to integrate new possibilities of renewable energies and latest technologies. Upgraded designations and indicators could be more effective in modern development regulation and urban management, and therefore release the power of regulatory planning in the new territorial spatial planning system.

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