frontiers | Frontiers in Environmental Science

TYPE Original Research
PUBLISHED 13 December 2022
DOI 10.3389/fenvs.2022.1064852

OPEN ACCESS

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SPECIALTY SECTION
This article was submitted to Environmental Systems Engineering, a section of the journal Frontiers in Environmental Science

RECEIVED 08 October 2022
ACCEPTED 28 November 2022
PUBLISHED 13 December 2022

CITATION
Hu Y and Lin Y (2022), Comparison of green building policies and regulations between central and local governments of China: Analysis based on text similarity.
Front. Environ. Sci. 10:1064852.
doi: 10.3389/fenvs.2022.1064852

Comparison of green building policies and regulations between central and local governments of China: Analysis based on text similarity

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The development of green buildings, as the focus of the construction field, is an inevitable choice to achieve the goal of carbon peaking and carbon neutralization. From the perspective of text similarity, this paper conducts a comparative study on the 14th Five-Year Plan for Building Energy Conservation and Green Building Development issued by the Ministry of Housing and Urban-Rural Development of the PRC in 2022 and sixteen local regulations on green buildings at provincial levels. The results show that: First, promoting energy-saving and green transformation of existing public buildings, promoting new green construction methods, strengthening green building management system construction and other contents, have the highest similarity value, indicating that these three contents have the highest overall notices in the legislation formulation level of green buildings in different regions; Second, the legal texts formulated by Tianjin and Shanghai are more in line with the requirements of the 14th Five-Year Plan than those of other provinces, showing the forward-looking nature of local legislation; Lastly, through data analysis, it is found that the average similarities of the three deployments of green buildings have small differences, but there are large differences between regions. Jiangxi, Qinghai and Guangdong have some outstanding contents, forming regional characteristics according to local conditions, showing the differences of local legal texts. Since the Plan is the latest national guidance, it requires local regulations to refine and implement the contents of the Plan. Based on the comprehensive comparative analysis of the text, it is recommended that all localities should check and fill gaps according to the Plan, improve the key task systems, and use local standards to build legal guarantee tailored to local conditions.

Abbreviations: BOW, bag of words; CSTEC, the China-Singapore Tianjin Eco-City; GBRTs, green building rating tools; ICTCLAS, Institute of Computing Technology, Chinese Lexical Analysis System; IS, indicator system; LDA, Latent Dirichlet Allocation; MOHURD, the Ministry of Housing and Urban-Rural Development of the PRC; QES, quantitative evaluation system; R&D, research and development; SMCHURD, Shanghai Municipal Commission of Housing and Urban-Rural Development of the PRC; SMPC, Shenzhen Municipal People's Congress; TF-IDF, term frequency–inverse document frequency.

KEYWORDS

text similarity calculation, green building, carbon peaking and carbon neutralization, policy and law comparison, local legislation

1 Introduction

Addressing climate change is a major issue faced by all countries in the world. China has become the world's largest energy consumer and polluter (Jiao et al., 2022). The construction field, which accounts for half of China's energy consumption, is facing both opportunities and challenges in carbon emission reduction. In the past decade, China has gradually accelerated its green building actions, and shifted its focus from "building energy conservation" to the development of "green buildings" with higher requirements. Green buildings have made great progress in China: During the "12th Five-Year Plan" period (2011–2015), there were 3,867 green building identification projects in China; and during the "13th Five-Year Plan" period (2016–2020), China entered the stage of comprehensive and rapid development of green buildings, with about 3,500 new projects added every year (Huang and Gao, 2022). By the end of 2020, the accumulated green building area has exceeded 6.6 billion square meters in China, and the proportion of area of newly built green buildings in cities and towns in the new building of that year has reached 77% (MOHURD, 2022).

In March 2022, the 14th Five-Year Plan of China's Green Buildings was issued, which put forward higher requirements for the high-quality development of green buildings. The latest Plan at the central level in China still needs to be implemented by local green building legislation. The existing effective local green building legislations were all formulated before the promulgation of the 14th Five-Year Plan, and will continue to be implemented after the 14th Five-Year Plan. It is unclear that, to what extent the local regulations are consistent with the national Plan. Based on this, this paper tends to explore the differences between the existing local green building legal texts and the latest central green building Plan, from the perspective of text similarity method based on the common measurement, and the text similarities between local green building legal texts are also compared to analyze the progresses of local green building legislations, the differences between regions, and local characteristics.

There is no uniform definition of "green building." The World Green Building Committee believed that "green building" refers to a building that can reduce or eliminate negative impacts and have positive impacts on climate and natural environment, during its design, construction or operation (World Green Building Council, 2022). China's Assessment Standard for Green Buildings defined green buildings as high-quality buildings that can save resources, protect environment, reduce pollution, provide healthy, applicable and efficient use space for people, and maximize the harmonious coexistence of human and nature, within the whole life cycle of the building (MOHURD, 2019). Both of them agreed that the green building evaluation is the green performance evaluation of green buildings in the whole process of design, construction, operation and demolition, involving safety and durability, health and comfort, convenient life, resource conservation (land saving, energy saving, water saving, material saving) and environmental livability. At present, many scholars have conducted comparative studies on the general information, indicator system (IS), and quantitative evaluation system (QES) etc. of the green building rating tools (GBRTs) (Wu et al., 2016; Doan et al., 2017; Huo et al., 2017; Illankoon et al., 2017; Ding et al., 2018a; Lu et al., 2019; Zhang et al., 2019; Chi et al., 2020; Franco et al., 2020; Umaroğulları et al., 2020).

In addition, some scholars also used text analysis method to study the green building issues, mainly including policy metrological analysis, content analysis and word effect analysis. Some studies used policy metrological analysis. For example, Wang Y. et al. (2020) used bibliometric analysis methods to sort out and analyzed the changes of 136 prefabricated buildings policies published in China from 1956 to 2019. Zhao et al. (2019) summarized 2,980 articles on green building research published from 2000 to 2016 through bibliometric methods. Santos et al. (2019) conducted information metrological analysis on 317 journal articles to observe literature trends, identify top journals and researchers, determine word frequency and analyze the dispersion situation of publications in previous years. The content analysis method were used as follows: Qiang (2020) takes Shaanxi Province as an example to study the supply and demand matching of green building policies based on the content analysis method; Wang Z. et al. (2020) analyzed the normative documents of green building design in the Yangtze River Delta based on the content analysis method; Zhang et al. (2022) selected 40 green building designers, conducted in-depth interviews with grounded theory methods, extracted in-depth interview data, and formed four core categories: technical identification, human resources, technical management, and economic factors; Liu et al. (2020) reviewed 191 policy documents on building transformation in China, discussed the policy characteristics based on content analysis, and revealed the effectiveness of China's building policies on accelerating the popularization of green transformation; Zhao and Chen. (2020) applied the grounded theory to reveal the influencing factors and mechanism of green housing purchase intention. The word effect analysis method were used as follows: Wu (2020) collected and analyzed microblog user information related to green buildings, as well as popular posts and comments, and

explored the public's emotion towards green buildings by combining LDA (Latent Dirichlet Allocation)theme modeling and emotion analysis; Wu et al. (2021) proposed a method based on LDA text mining to examine the research field of green buildings in China, and investigated the research trend according to the research topics determined at different stages; Ding et al. (2018b) used LDA algorithm to model and analyze 1,600 research articles and engineering reports in the field of architecture. Shen et al. (2017) made the first attempt to integrate text mining techniques into a case-based reasoning system that uses text mining methods to extract text features from case reports and assist in case retrieval to aid in decision making in the green building design process. The abundant text metrological analysis method adds many choices for the green building research, and the overall research status shows the characteristics of multi perspectives, multi methods, as well as having the features of both breadth and depth.

This paper attempts to compare and analyze the similarities and differences between the central and regional green building development requirements by calculating the similarity between the "Plan" and provincial legal texts. Text similarity analysis is one of the word efficiency analysis methods. Text similarity calculation refers to comparing the similarity between two or more entities (including words, short texts and documents) through a certain strategy to obtain a specific quantitative similarity value (Wang et al., 2019). Text similarity has been used to measure the differences and similarities between texts (Paraschiv et al., 2015; Mahmood et al., 2017). Therefore, string matching and word matching have become the basic methods for calculating text similarity. With the development of natural language processing technology, stem extraction, no longer used word removal, part-of-speech tagging and other methods have been introduced into text similarity calculation, and combined with various weighting and regularization strategies, combined with information that goes deep into the semantic level to form the current commonly used methods (Huang and Che, 2019). Chinese scholars evaluated the commonness of Chinese policies, laws, systems through the method of text similarity, which confirmed the feasibility of this method (Zhang and Ma, 2021; Ma and Zhang, 2022; Xu and Liu, 2021). At present, there is no comparative study on the central and local green building policy and legal texts from the perspective of text similarity.

The innovation and contribution of the paper lie in the following three perspectives compared with other studies. This paper is the first to apply the text similarity analysis method to the field of green building policy comparison, which is different from the national comparison of the above green building tools and other research using text mining methods. Second, the comparison between the central level and the local level is also a new perspective. This paper selects the plan text at the front end and the local legal text at the end to conduct the analysis, which is a plan and legal structure chain of "central planning—central legislation (currently there is no central level legislation for green buildings)—local planning—local legislation," so as to observe the direction of local regulation modification. Third, this study also contributes to the literature on green buildings. Green building has become a common initiative to mitigate climate change and resource consumption globally. The development of green buildings in China is an inevitable choice to achieve the goals of "carbon emission reduction" and "sustainability." As a developing country with huge resource consumption, the direction of China's green building policies and regulations is closely linked to the global environmental governance process. China's institutional experience in developing green buildings can serve as a reference for other countries in developing sustainable buildings.

2 Sample selection

As shown in Table 1, the development of the central level green building plan is a gradual process from weak to strong, point to the whole, and voluntary implementation during the "11th Five Year Plan" period to mandatory implementation in proportion in some regions during the "12th Five-Year Plan" period, to large-scale enforcement in proportion throughout the country during the 13th Five-Year Plan period, finally to put forward new requirements for high-quality and all-fields development of green buildings in the 14th Five-Year Plan period. The green building standards and supporting documents have been gradually improved, covering all aspects of design, construction, operation, transformation and evaluation. Since the 13th Five-Year Plan, the promotion of green buildings has been listed as an important task at the central level, like building energy conservation. The "14th Five-Year Plan" not only extends the tentacles from new buildings to green transformation of existing buildings, but also adds green construction methods, green cities and other contents as important tasks. At present, the latest "14th Five-Year Plan" guides the new direction of local green building development at the central level. How to close the gap between the task (goal) at central level and the current local regulations (means) has become the starting point of the text comparison in this study.

Therefore, the 14th Five-Year Plan for Building Energy Efficiency and Green Building Development (hereinafter referred to as the Plan), which takes green buildings as the key construction direction, is the first category of research object of this paper. It is a policy text of the central level. To achieve this goal, the Plan proposed three major deployment contents, namely, nine key tasks, five supporting measures and three organizational implementation requirements. The nine key tasks include a total of 13 secondary specific indicator tasks for building energy conservation and green buildings. Among them, "building energy conservation" is a binding task for China to

TABLE 1 History of the releases of special planning documents on green buildings by the Ministry of Housing and Urban-Rural Development (MOHURD) of the People's Republic of China.

Time	Name of the plan	Tasks on green buildings	Supporting legal documents and standards
The Eleventh Five-Year (2005–2010)	No special plan, but the "11th Five-Year Plan" proposed building energy conservation task	In this period, the mode of "mandatory implementation of building energy conservation standards" + "voluntary implementation of green buildings" was implemented. This document has no binding tasks for green buildings	MOHURD issued the Evaluation Standards for Green Buildings (2006), which preliminarily outlined the concept of green buildings
The Twelfth Five-Year (2011–2015)	Special Plan for Building Energy Conservation during the 12th Five-Year Plan Period	It took the promotion of the development of green buildings as one of the key tasks. It required that 50% of the new real estate projects in 14 provinces and cities shall meet the green building standards	MOHURD issued the Action Plan for Green Building (2013), and released the Evaluation Standard for Green Construction of Building Engineering (2011), the Code for Green Design of Civil Buildings (2011), the Code for Green Construction of Building Engineering (2014), and the Evaluation Standard for Green Building (Revised Edition) (2014), etc. The green building standard gradually covers all aspects of building design, construction and evaluation
The thirteenth Five-year (2016–2020)	The 13th Five-Year Plan for Building Energy Conservation and Green Building Development	One of the main tasks is to "promote the development of green buildings in both quantity and quality". It also put forward the green building multiplication plan (it is planned that by 2020, new green buildings in cities and towns will account for more than 50% of new buildings, and the newly added green building area will be more than 2 billion square meters), green building quality improvement action (more than 80% of construction projects of two star level and above, and more than 30% receive operational labels), development plan for the whole industrial chain of green buildings (by 2020, the proportion of green building material utilization in new buildings will exceed 40%; the proportion of prefabricated buildings in new buildings will exceed 15%)	Standards and specifications such as the Evaluation Standard for Green Transformation of Existing Buildings (2015) and the Technical Code for Operation and Maintenance of Green Buildings (2017) was released, which provided technical support for the operation and transformation of green buildings. In 2019, the Evaluation Standard for Green Buildings was revised, and the five evaluation index systems of safety and durability, health and comfort, convenient for life, resource conservation and livability were reconstructed
The 14th Five Year (2021–2025)	The 14th Five-Year Plan for Building Energy Conservation and Green Building Development	Propose high-quality development of green buildings (by 2025, new buildings will fully implement green building standards), and the "mandatory + voluntary" model will be adopted to promote star rating green buildings; Apply energy-saving and green transformation of existing public buildings; Promote new green construction methods; Promote the application of green building materials; Promote green city construction and other tasks	

Source: Collected and collated from the website of the MOHURD of the People's Republic of China, https://www.mohurd.gov.cn.

reduce building energy consumption in the early period. After the "green building" action was created in the later period, it is still parallel to the "green building" task. The identification requirements for "green buildings" in terms of energy conservation are higher than the building energy conservation standards. Building energy conservation and green buildings have different tasks and objectives: the building energy conservation task focuses on the implementation of mandatory energy conservation standards for new buildings, the energy conservation transformation of existing residential buildings in northern heating areas, the energy conservation transformation of existing residential buildings in hot summer and cold winter areas, the construction of public building energy conservation supervision and management system, the utilization of renewable energy and the construction of building energy conservation systems and mechanisms; The task of green building focuses on the development of appraisement label, enforcement and promotion, and the construction of green building systems and mechanisms (MOHURD, 2020). According to the distinction between green buildings and building energy conservation tasks, excluding the task of "building energy conservation", the 13 tasks in the Plan leaved six key tasks of "green buildings": 1) strengthening the construction of high-quality green buildings; 2) improve the operation and management system of green buildings; 3) promote energy-saving and green transformation of existing public buildings; 4) promote new green construction methods: 5) promote the application of

green building materials; 6) promote the construction of green cities. The five supporting measures include: 1) improve the system of regulations and standards; 2) implement incentive policies; 3) strengthen the system construction (the "system construction" indicator refers to the green building label management and green building materials certification, the same as below); 4) highlight the drive of technology innovation; 5) innovate the project quality supervision and management mode. Three organizational implementation requirements refer to: 1) strengthen organization and leadership; 2) strict performance evaluation; 3) strengthen publicity and training. This paper extracts these parts to generate the policy framework, and takes it as the comparison object. In this paper, "six key tasks," "five supporting measures" and "three implementation requirements" are collectively referred to as "three major deployments," totaling 14 indicators.

In China, the central level planning and local legislation are linked as goals and means. The central planning needs to be transformed into local legislation for implementation, and local legislation is the guarantee for the implementation of the central planning (Yan, 2015). The policy of "central planning" generally realizes the "legalization of planning" through the sequence of "central planning—central legislation—local planning—local legislation." With searching the official websites of local governments in mainland China and the Pkulaw Database, we selected the sample range based on four considerations: First, the division of local building energy conservation legislation and green building legislation. Based on the parallel implementation mechanism of "building energy conservation" and "green building," half of the regions that have issued green building legislation complying with the task division at the central level, separately promote the green building and building energy conservation tasks with separate legislation models. Here, focusing on the task of green buildings, we only retain the relevant parts of green buildings, so as to avoid confusion in the follow-up content comparison caused by multiple legal documents in one province; Second, only seven provincial administrative units have released the text of the local 14th Five-Year Plan for green buildings till now, and the rest of the regions have just integrated green buildings into the building planning as fragments. Such sample size is not enough to support the purpose of studying the gap between the local level and the central level. The third is that although some legal texts are related to green buildings, they only regulate a single task, such as the Administrative Measures of Beijing on Green Building Labels. They are lack of most of the task contents, and thus the comparability is weak; finally, we collect only the legal texts that are currently effective and have continuous forces. For example, in 2020, 13 provinces formulated regional green building action plans, but these local normative documents will be "retired" in 2022, far less effective than local regulations. After eliminating the documents that do not meet the requirements, a total of 16 existing effective provincial regulation texts covering a wide range of content were selected. These texts are regarded as representatives of the local level. They are the objects of comparison in this paper. See Table 2 for details.

3 Research methodologies and processes

Text similarity is a widely used research method (Chen and Jiang, 2017), which has both theoretical support and application practices. Based on information theory, Lin (1998) clarified that the commonness of text similarity is proportional to the value of similarity, and it is inversely proportional to the difference. That is, the greater the commonness, the smaller the difference, and the higher the similarity. At present, the proposed text similarity calculation methods mainly include BOW (bag of words) model-based method, topic model-based method, ontology-based method, and word vector-based method. Among them, the word bag model is often used to calculate the similarity of texts in small-scale corpora (Li and Li, 2018). It is an unsupervised process, which does not require a large number of training data, and has the advantage of low computational complexity. This is consistent with the characteristics of small data set and strict language specification of the research objects in this paper. In order to overcome the shortcoming that the bag of words model ignores the grammar, word order and other elements of the text, scholars mixed two or more methods to calculate the text similarity. In this paper, we learned from Zhang et al. (2020), and selected the method of combining Doc2Bow (Doc2bow is a method for processing text in Gensim module) and TF-IDF (term frequency–inverse document frequency) to calculate the similarity of the policy and legal texts. Based on the assumption that the higher the similarity value between texts, the greater the commonality, the research methods and processes are divided into five parts: policy text collection, text preprocessing, similarity calculation, policy framework construction, and policy comparison research. It should be noted that this method still has limitations, because sentence similarity comparison is based on the feature words (keywords) after text preprocessing. If the feature words are too scattered (for example, three feature words are scattered to three sentences), the similarity value will be reduced, so it needs to be comprehensively analyzed in combination with the actual situation. The specific process is shown in Figure 1.

(1) Text collection: We collected the "14th Five-Year Plan of Green Buildings" from the official website of the central government, and collected the currently valid provincial legal texts of green buildings from the local government websites and the Pkulaw Database. The information stored in the corpus could be divided into meta information, content information and sentence fragment information.
(2) Text pre-processing: The new word extraction function in ICTCLAS (Institute of Computing Technology, Chinese

TABLE 2 Provincial regulations of green buildings in China.

Year	Region	Names of the regulations
2015	Jiangxi	Measures of Jiangxi Province on Energy Conservation of Civil Buildings and Promoting the Development of Green Buildings
2017	Qinghai	Measures of Qinghai Province for Promoting the Development of Green Buildings
2018	Tianjin	Stipulations of Tianjin Municipality on the Management of Green Buildings
2018	Liaoning	Regulations of Liaoning Province on Green Buildings
2019	Shandong	Measures of Shandong Province for Promoting Green Buildings
2019	Inner Mongolia	Regulations of Inner Mongolia Autonomous Region on Civil Building Energy Conservation and Green Building Development
2020	Hebei	Regulations of Hebei Province on Promoting the Development of Green Buildings (Revised in 2020)
2020	Zhejiang	Regulations of Zhejiang Province on Green Buildings (Revised in 2020)
2020	Guangdong	Regulations of Guangdong Province on Green Buildings
2021	Ningxia	Regulations of Ningxia Hui Autonomous Region on the Development of Green Buildings (Revised in 2021)
2021	Jiangsu	Regulations of Jiangsu Province on the Development of Green Buildings (Revised in 2021)
2021	Fujian	Regulations of Fujian Province on the Development of Green Buildings
2021	Hunan	Regulations of Hunan Province on the Development of Green Buildings
2021	Anhui	Regulations of Anhui Province on the Development of Green Buildings
2021	Shanghai	Measures of Shanghai Municipality on the Management of Green Buildings
2021	Henan	Regulations of Henan Province on Green Buildings

Source: Collected from the official websites of the provincial governments in Mainland China and the Pkulaw Database (http://www.pkulaw.com).

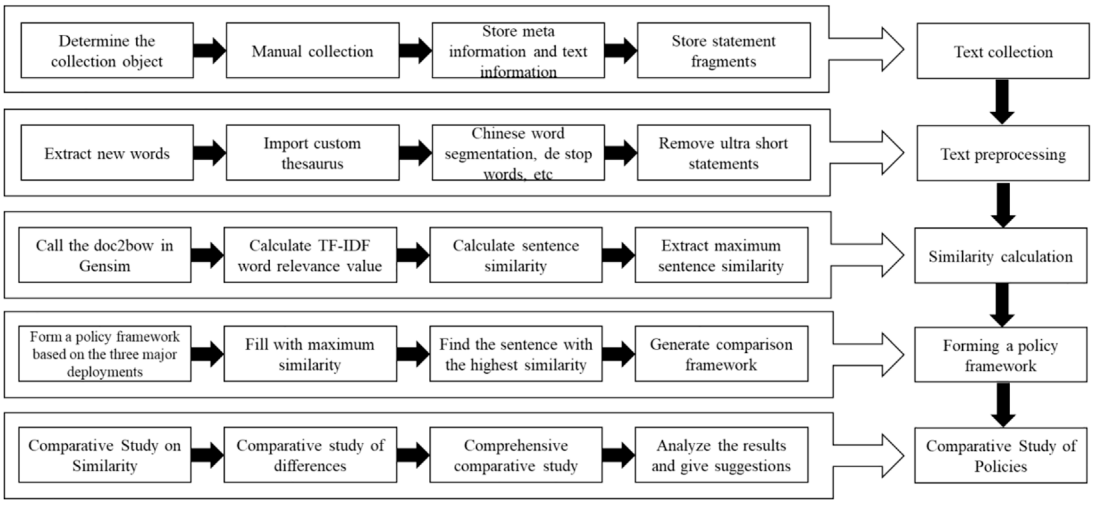

FIGURE 1
Research flow chart based on the text similarity calculation.

Lexical Analysis System) of the Chinese Academy of Sciences was used to obtain text keywords, and 138 user-defined vocabularies are formed in combination with self-built thesaurus. Subsequently, the Jieba tool of Python language was used to filter the text by word segmentation, stop words removal, and ultra-short words of incomplete sentences removal, making it a text to be compared and analyzed. Considering that stipulations in legal texts are sometimes refined, and very detailed language expression will affect the results of comparison, the word frequency was adjusted to

one to filter unimportant words so as to make keywords more prominent, which is conducive to comparison.

(3) Similarity calculation: In this paper, we took the Plan as a comparative text, and used the BOW model, TF-IDF model and cosine similarity in the Gensim tool of Python language to calculate the sentence similarity between the three major deployment contents in the Plan and the legal texts of different regions, and generated a similarity matrix.

(4) Generation of policy framework: We took the three major deployments ("six key tasks," "five supporting measures," and "three implementation requirements") after removing the "building energy conservation" task from the Plan, as the first level indicators, and took the 14 specific contents of the three major deployments as the second level indicators. The sentence with the highest similarity was extracted as the sample to be analyzed, and filled the maximum similarity value in the sentence into the policy framework.

(5) Policy comparison study: The text similarity calculation method compares the feature words in the word bag. Results of data analysis showed that, the higher the similarity value, the greater the commonality between texts. The results of text similarity calculation can reflect the similarities and differences between the three major deployments of the Plan and the implementation of policies in different regions to a certain extent.

4 Empirical study

The sentence position and value of the maximum similarity between the regional green building legal text and the central plan are shown in the Supplementary Appendix S1.

4.1 Comparative analysis of local regulations based on the three major deployments of the plan

The Plan is a top-level document guiding China's strategies and actions for green and low-carbon development in the building sector. The six key tasks transform the expected aims of green buildings into operational implementation paths, which are the core parts of the Plan; Supporting measures as well as the implementation requirements guarantee the six key tasks. The key tasks, supporting measures and implementation requirements are the three major deployments to achieve the objectives of the Plan. In this paper, we take its specific content as a reference, and make comparative analysis with the legal texts of green buildings in different regions, in order to explore the commonalities and differences of policy formulation. The specific contents of the three deployments are analyzed as follows.

4.1.1 Deployment one: Key tasks of green buildings

The key tasks of green buildings involve the construction of high-quality green buildings, the operation and management system of green buildings, the energy-saving and green transformation of existing public buildings, new green construction methods, the application of green building materials, and green city construction. The similarity comparison values are as follows in Table 3.

(1) High quality construction. The task of "strengthening the construction of high-quality green buildings" is rich in connotation. It involves the life cycle of green buildings from the low carbon design stage to the standardized construction process. It not only aims to promote the large-scale development of urban green buildings, but also encourages the green construction of rural housing. The value range of this part is .3188–.7773, with the highest value of Hunan (.7773). The Regulations on the Development of Green Buildings in Hunan Province was issued in 2021, which specifies the practical significance and promotion arrangement of green building development to help reduce carbon emissions. In particular, it clarifies that, the responsibility of the competent department "should" prepare the provincial green rural housing construction guidelines and construction design guidelines, so as to encourage and promote green rural housing. "Promoting green rural housing demonstration construction" is a key project for the development of green buildings in Hunan in the next a few years. It is estimated that by 2025, there will be 30 green rural housing demonstration villages in Hunan Province (Hunan Provincial Department of Construction of the PRC, 2022).

(2) Operation and management system. "Improving the green building operation management system" requires improving the green building operation efficiency during the building operation stage, through property management improving, user evaluation and feedback, intelligent management platform monitoring and statistical analysis measures. The value range of this part is .3508–.6778, and Fujian has the highest value of .6778. Fujian Province has clearly established the green building operation evaluation system in the Green Building Development Regulations of Fujian Province issued in 2021, and the government provides funds to ensure the operation of the building energy consumption monitoring platform.

(3) Green transformation. It focuses on the existing public buildings: strengthen the operation supervision and management system of public buildings, gradually implement the energy usage management of public buildings, continuously promote the energy efficiency of public buildings to improve the construction of key cities, and establish the operation commissioning system of public

TABLE 3 Comparison of similarity values of key tasks of green buildings.

Year	Region	Key tasks					
		Six concrete contents					
		High quality construction	Operation and management system	Green transformation	Green construction method	Green building materials	Green city
2015	Jiangxi	.4342	.5881	.4203	.4623	.3476	.3675
2017	Qinghai	.5065	.5176	.4537	.8293	.6414	.5065
2018	Tianjin	.6733	.6226	.6011	.7833	.8284	.4699
2018	Liaoning	.3519	.4199	.5355	.6677	.3477	.3243
2019	Shandong	.4578	.4419	.5002	.5385	.4474	.4761
2019	Inner Mongolia	.4616	.5593	.4840	.4704	.5399	.4478
2020	Hebei	.4338	.3508	.3356	.5607	.4314	.3307
2020	Zhejiang	.4705	.5361	.5871	.7363	.3547	.4605
2020	Guangdong	.5132	.4264	.6857	.3735	.4132	.4195
2021	Ningxia	.4754	.4927	.5990	.6244	.5038	.3804
2021	Jiangsu	.4742	.5786	.6083	.5681	.3183	.3673
2021	Fujian	.3978	.6778	.6420	.4989	.4011	.3789
2021	Hunan	.7773	.5156	.5637	.3699	.3243	.4240
2021	Anhui	.6349	.4519	.7419	.5426	.4324	.3257
2021	Shanghai	.5092	.4955	.5204	.8087	.6793	.3908
2021	Henan	.3188	.4222	.5463	.4091	.3224	.3965

buildings. The value range of this part is .3356–.7419, and Anhui Province has the highest value of .7419. In the Regulations on the Development of Green Buildings in Anhui Province issued in 2021, Anhui Province emphasized the promotion of the construction of the energy consumption supervision platform for public buildings, and strengthened the work of public buildings in real-time energy consumption monitoring, statistics, publicity, energy audit, etc., which is an important link in the green transformation of public buildings. The province with the second highest value is Guangdong Province, with a value of .6857. Guangdong Province adopted the measure of limiting the amount of energy consumption of public buildings to promote green transformation. Guangdong clearly listed the scope of the restricted "public buildings" as "large-scale public buildings, office buildings of state organs, and other public buildings invested and constructed by state-owned funds," and also authorized prefecture level cities to formulate stricter quota requirements than those at the provincial level, which is conducive to reducing the carbon emissions of buildings.

(4) Green construction method. The "promotion of new green construction method" will promote mature and reliable steel structure, fabricated concrete and wood structure building structures according to different building types. The design, production and decoration of prefabricated buildings are the future development direction. The value range of this part is .3699–.8293, with the highest value of Qinghai (.8293). The Measures of Qinghai Province for Promoting the Development of Green Buildings issued in 2017 encourages the integration of personalized decoration and industrialized decoration of commercial housing, which is consistent with the content of the Plan on the development of prefabricated decoration. Data analysis shows that Shanghai, Tianjin and Zhejiang also have high values, which are .8087, .7833 and .7833, respectively, but the emphasis of the three regions are different. Shanghai pays attention to the mature green building scheme in the design stage; Tianjin focuses on promoting prefabricated buildings such as prefabricated concrete structures, steel structures and modern wood structures, to achieve the promotion and application of

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TABLE 4 Comparison of similarity values of supporting measures and implementation requirements of green buildings.

Year	Region	Supporting measures				Implementation requirements			
		Five concrete contents				Three concrete contents			
		Regulation and standard	Incentive policies	System construction	Technology innovation	Quality supervision and management	Organization and leadership	Performance evaluation	Publicity and training
2015	Jiangxi	.2784	.3291	.5048	.5881	.4054	.4754	.6414	.6431
2017	Qinghai	.3842	.3247	.4885	.3764	.3312	.4830	.3371	.3642
2018	Tianjin	.7012	.7848	.5331	.6412	.6835	.4510	.4780	.3429
2018	Liaoning	.3442	.4829	.5933	.3415	.4467	.5116	.4245	.6291
2019	Shandong	.3811	.3635	.4709	.5152	.5941	.5841	.5012	.3050
2019	Inner Mongolia	.3873	.5690	.7472	.4013	.3083	.5554	.4810	.4659
2020	Hebei	.6298	.4854	.6370	.5097	.4987	.3773	.4467	.4345
2020	Zhejiang	.3745	.3953	.6806	.2310	.3029	.4668	.4908	.4109
2020	Guangdong	.3985	.4687	.4896	.4021	.3483	.4302	.7682	.7577
2021	Ningxia	.6505	.4280	.4510	.3389	.3618	.4879	.5023	.4062
2021	Jiangsu	.5003	.5053	.5332	.4412	.5521	.4605	.2882	.4557
2021	Fujian	.4987	.5140	.6341	.2716	.3981	.5159	.3428	.5579
2021	Hunan	.6427	.2989	.4435	.3374	.4561	.5097	.4069	.7839
2021	Anhui	.4266	.3161	.5354	.4663	.4444	.3982	.6870	.6051
2021	Shanghai	.5172	.6091	.9150	.5593	.3877	.5417	.4895	.4488
2021	Henan	.2786	.3736	.4920	.2970	.3559	.4541	.7858	.3749

new green construction methods and technologies; Zhejiang, like Qinghai, take outstanding measures in decoration. In general, about half of the regions have high and concentrated similarity values in integrated decoration.

(5) Green building materials. The requirements of "promoting the application of green building materials" are: first, increase R&D investment and promote environmentally friendly building materials products and relevant application technologies; second, the government takes the lead in using green building materials and takes the lead in demonstration. The value range of this part is .3183–.8284, with the highest value of Tianjin (.8284). Tianjin encouraged the construction of passive ultra-low energy consumption green buildings and the use of renewable and recyclable building materials in the Tianjin Green Building Management Regulations issued in 2018, and for green building projects, green building materials and equipment must be given priority.

(6) Green city. "Promoting green city construction" requires that green low-carbon city construction plan and special green building plan should be formulated, based on an objective assessment of the actual situation of urban building energy consumption and carbon emissions; It requires to promote the implementation of projects such as low-carbon community construction, green transformation of existing buildings, and energy efficiency improvement of buildings, so as to achieve comprehensive and large-scale development of green buildings. The value range of this part is .3243–.5065, and the overall value is low, with the highest value of Qinghai (.5065). The Plan takes "green city construction" as one of the key tasks, which is rich in content, but the legal texts of different regions currently involve less in this content. In the Measures of Qinghai Province for Promoting the Development of Green Buildings issued in 2017, Qinghai has slightly expanded the objects of green city planning and construction - defining four categories of new region construction in urban areas, small town construction, large residential area construction, and shantytown reconstruction projects.

4.1.2 Deployment two: Supporting measures for the key tasks

The supporting measures involve five aspects, including improving the regulation and standard system, implementing incentive policies, strengthening the system construction, highlighting the drive of technology innovation, and innovating the project quality supervision and management mode. The similarity comparison values are in Table 4 as follows:

(1) Regulation and standard. The "improving regulation and standard system" includes the improvement of laws and regulations, local regulations and rules, national standards and local standards related to green buildings. The sample selected in this paper represents the degree of similarity of local legislation for the implementation of the Plan. The value range of this part is .2784–.7012. Tianjin has the highest value (.7012). Tianjin stipulated in the Regulations on the Management of Green Buildings in Tianjin that, the government should guide the development of green buildings step by step, the market mechanism should participate in the promotion, and the legal responsibility should be clearly divided, which is exactly the same as the Plan's proposal to implement the main responsibilities of all parties and standardize the development of green buildings.

(2) Incentive policies. This part proposes that the government should financially support the development of green buildings, and green banking as well as green insurance also should play their roles. In addition, the government should improve the government procurement standard of green building materials, and explore the carbon emission trading mechanism of large buildings. The value range of this part is .2989–.7848, and the value of Tianjin is still the highest (.7848). Tianjin has allocated special funds for technology R&D, application promotion and reward for green buildings.

(3) System construction. "Strengthening the system construction" means to innovate, extend and improve the existing management system. In the Plan, it only refers to improving the identification and management system of green building label, and establishing and improving the credit mechanism of green building materials. The value range of this part is .4435–.9150, with the highest value of Shanghai (.9150). After the promulgation of the Shanghai Green Building Management Measures in 2021, Shanghai implemented the system of voluntary declaration of green building label, which is consistent with one of the key points of the Plan. The second is Inner Mongolia, with the value of .7472. After the promulgation of Regulations on Energy Conservation and Green Building Development of Civil Buildings in Inner Mongolia Autonomous Region in 2019, Inner Mongolia Autonomous Region implemented the green building material label evaluation system, which has promoted the application of green building materials, as well as the development of green building material industry.

(4) Technology innovation. "Driven by technology innovation" is to build a technology innovation system that is market-oriented, government based, enterprise oriented, and deeply integrated with industry, university and research institutions. The value range of this part is .2130–.6412, and the overall value range is low, with the highest value of Tianjin (.6412). However, compared with the detailed content in the Plan, Tianjin's legal text only refers roughly to supporting green technology R&D, which is far from enough.

(5) Quality supervision and management. "Innovative project quality supervision and management mode" includes

encouraging the use of new "Internet + supervision" mode, promoting visualization technology, and using insurance means to prevent and control project quality risks. The value range of this part is .3029–.6835, and the overall value range is low, with the highest value of Tianjin (.6835). Compared with the Plan, in which innovative supervision and management mode were required, although Tianjin implements completion acceptance supervision on green buildings, it does not require the application of modern technical monitoring means. Similar problems also exist in other local legislations.

4.1.3 Deployment three: Implementation requirements for the key tasks

The organization and implementation involve strengthening the organization and leadership, strict performance evaluation, and strengthening publicity and training. The similarity comparison values are shown in the above Table 4.

(1) Organization and leadership. This part clarifies the overall coordination of housing and urban-rural construction departments, and promote the development of green buildings together with other government departments. The value range of this part is .3773–.5841, and the sample value difference is small, with the highest value of Shandong (.5841). In the Measures for Promoting Green Buildings in Shandong Province issued in 2019, Shandong specified that the competent housing and urban-rural construction departments at all levels in the province, together with the development and reform, industry and information technology, and natural resources departments, should organize the preparation of special plans for the development of green buildings, specify the development goals of green buildings, key development areas, prefabricated buildings and other contents, as well as determine the green building grade requirements for various new construction projects. Texts of other provinces have similar contents.

(2) Performance evaluation. "Strict performance evaluation" includes three categories: The first is the regular annual supervision, inspection and evaluation, and several special evaluations of urban-rural green buildings made by MOHURD; Second, the central government will evaluate the implementation of local governments from time to time; Third, local government departments regularly report their work. The value range of this part is .2889–.7858, with the highest value of Henan (.7858). In the Green Building Regulations of Henan Province issued in 2021, Henan clearly included the completion of green building objectives into the evaluation system. Data analysis shows that the value of Guangdong is relatively high (.7682). Guangdong also takes the development of green buildings as the content of performance evaluation of governmental departments.

(3) Publicity and training. "Strengthening publicity and training" proposes to mobilize multiple forces and multi-channel publicity to reach a general consensus. In addition, it also pointed out that training and teaching of professional technical courses should be built to cultivate professional talents. The value range of this part is .3050–.7839, with the highest value of Hunan (.7839). In the Regulations on the Development of Green Buildings in Hunan Province issued in 2021, Hunan proposed a variety of publicity methods to popularize green building knowledge and make the green lifestyle accepted by the people. It also asked the government to strengthen the introduction and training of green building talents. Guangdong is the next, with a value of .7577. Guangdong also carried out green building publicity in the form of green building project demonstration, product exhibition, technical exchange, design competition, etc., and promoted publicity and training with the help of the local Green Building Association.

4.2 Comparative analysis of local text according to the classification of the three major deployment contents of the plan

Statistical analysis of the regional text similarity data according to the 14 comparison items in the three major deployment contents of the Plan can help explore the commonness of deployment contents in the Plan with regulations of different regions. Based on the average data of specific indicators, the sample values are divided into three grades, and the specific analysis is in Figure 2 as follows.

The value of the first level is above .5. This level includes: operation and management system, green transformation, green construction method, system construction and performance evaluation. The average values are .5061, .5516, .5777, .5718, .5045, respectively. In terms of "improving the operation and management system" of green buildings, these regions have formulated requirements for managing the operation of green buildings and established an energy consumption supervision and management platform. However, compared with the Plan, the regions did not incorporate the daily operation requirements of green buildings into property management, nor established green building user evaluation and feedback mechanisms. The "energy-saving and green transformation" of existing public buildings is one of the focuses of regulation making in different regions, especially the corresponding construction of the supervision system. Most regions have made specific stipulations on the environmental requirements of green building operation, and established energy consumption monitoring platforms for public buildings to collect and monitor data. However, few regions can disclose energy consumption information like Anhui. In addition, on the whole, there are

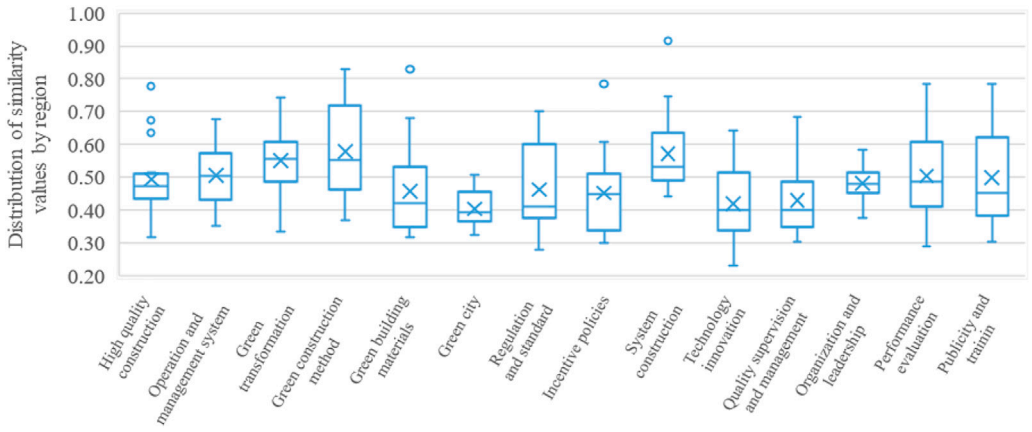

FIGURE 2
Numerical distribution of similarity of specific indicators of the 14th Five-Year Plan.

deficiencies in carrying out energy efficiency evaluation of public buildings, promoting low-carbon transformation of building facilities, and establishing commissioning system for public building operation equipment. These are exactly the directions of tasks proposed in the Plan. "promote new green construction methods," which is the most important task among the six key tasks in all regions. The regional average and median values of this task are the highest among the 14 comparison items. Although this task was highlighted only during the 14th Five-Year Plan period, the good performances of different regions show the legal foresight of local legislation. The average value of "strengthening system construction" ranks second among the 14 comparative items, and the sample values are relatively concentrated, which shows that "system construction" is highly valued in local legislation. However, compared with the rich requirements of "system construction" in the Plan, there is still room for further rules formulation or revision in different regions. Even Shanghai, which has the highest value, is not perfect in system design, and it still needs to improve the credit mechanism of green building materials. The sample values of strict "performance evaluation" have wide distribution range and a high average value, which indicates that most regions put the green building promotion work into the performance evaluation, but in some regions, it remains in the stage of special plan, and has not been included in the political performance evaluation.

The value of the second level is from .45 to .5. This level includes high quality construction, green building materials, regulation and standard, incentive policies, organization and leadership, publicity and training. The average values are .4932, .4583, .4621, .4530, .4814, .4991, respectively. With regard to the task of "strengthening high quality green buildings," all regions not only focus on the new large-scale construction of green buildings in cities, but also encourage the promotion of green rural housing in rural areas. The average and median values of these regions are low. The legal texts of different regions involve some contents of the Plan, such as star level green buildings, but the tasks of the new period need to be supplemented in time. In addition, there are three outliers in the figure, indicating that the stipulations in the three regions are more consistent with the contents of the Plan. The three outliers are explained from high to low as follows: The first outlier represents Hunan Province, which is the region with the most specific provisions for green rural housing among the 16 samples and is close to the content of the Plan. The second outlier represents Tianjin, which has a clear content in promoting star level green buildings on a large scale. The third outlier represents Anhui. Anhui Province proposes to apply information model technology to help the construction survey, design, construction and operation management at all stages. The average similarity of each region in the task of "promoting the application of green building materials" is low, and the only high score is Tianjin, which indicates that all regions need to promote the implementation of R&D and application for green building material products and technologies. The average value of improving "regulations and standards" is not high. The sample value span is large as shown in the figure, and the median value is lower than the average value, which indicates that the quality of detailed standards in different regions is uneven. The average value of "implementation of incentive policies" is low, indicating that although there are policy incentive measures in various regions, they are not comprehensive enough compared with the content of the Plan, and they do not fully cover the specific content. Although the value of Tianjin is particularly high, it only shows that some of the incentive policies in Tianjin have high coincidence with some contents in the Plan. In general, all regions need to further supplement and improve government incentive measures in accordance with the Plan. The sample

value of "strengthening organization and leadership" is the most concentrated, and the text contents in these regions are almost the same. The common point of the texts in different regions is that they clearly put forward that the competent departments of urban and rural construction should cooperate with other departments to promote green buildings, and the difference is the numbers of cooperative departments. The clearer the collaboration departments and the clearer the division of the work, the more conducive to promoting the large-scale development of green buildings. For "intensifying publicity and training," the sample values are widely distributed, which indicates that the similarity between the legal texts of different regions and the Plan is uneven. All regions more or less mentioned the publicity of green buildings, but some samples did not mention the training of green building practitioners.

The value of the third level is below .45. This level includes green city, technology innovation, and quality supervision and management. The average values are .4041, .4199, and .42971, respectively. The average similarity of each region in the task of "promoting green city construction" is the lowest, because there are only a few words in the texts of each region, like "creating green ecological city." Although the construction of "green city" is a new task proposed by the 14th Five-Year Plan, in fact, some regions have forward-looking policies. For example, Changsha City in Hunan Province, Tianjin Eco City, Jiangshan City in Zhejiang Province, Wuxi City in Jiangsu Province, and other 13 cities (Maigoo, 2022) have been selected as the "green city" of the United Nations. All regions still need to pay more attention to low-carbon and green cities in the future. The average value of "technology innovation" ranks 13th among all indicators. Although the texts in different regions mentioned supporting the R&D of green building technology, the contents are far less detailed than the Plan. The average value of "innovative project quality supervision and management mode" ranks 12th. Although it has been mentioned in different regions that the government and the market are parallel, and the project quality supervision and management responsibilities should be implemented, the "Internet + supervision and management" mode has not been established, the visual technical disclosure has not been carried out, and the insurance means have not been introduced to prevent the project quality risk.

4.3 Comparative analysis on the similarity of legal texts between regions

4.3.1 Comparative analysis of average similarity of legal texts in different regions

The higher the similarity value between the regional regulation text and the Plan, the more it can reflect the compatibility between the regional regulations and the tasks of the Plan. The similarity data of legal texts in the regions are statistically analyzed for the 16 regions, and the results are divided into three grades based on the average of the similarity values of all regions, as shown in Figure 3.

The value of the first level is between .55 and .65. Tianjin and Shanghai implemented the efficient resource allocation mode and achieved a win-win development between economic development and pollution control (Zhang et al., 2021). Tianjin and Shanghai have the most outstanding values. Tianjin has attached great importance to green buildings for a long time, and the China-Singapore Tianjin Eco-City (CSTEC) is an excellent example. The Eco-City is a strategic cooperation project between the governments of China and Singapore. It is the first urban area putting forward in China to have the goal of 100% green building (CTEAC, 2015). In 2014, it was selected into the first batch of "National Green Building Bases" and became the only region in the northern part of China to win this honor (CTEAC, 2014). The CSTEC Green Building Operation and Management Guidelines issued in July 2018 is the first green building standard system in design, construction, evaluation and operation of green buildings in China (CTEAC, 2018). In addition, CSTEC was the first to adopt the dual mechanism of "terms + score" to evaluate the final grade of green buildings (CTEAC, 2015). These measures have accumulated sufficient experiences for the large-scale development of green buildings in Tianjin, provided a solid foundation for Tianjin to issue relevant regulations, and provided valuable references for national policy formulation. Therefore, even though the Tianjin Green Building Management Regulation was issued in 2018, its content was formulated comprehensively, and its similarity value with the Plan was the highest among all samples (.6139). In recent years, Shanghai implemented 100% green building standards for new buildings, implemented special review system for green buildings in the review of construction drawings, and ensured that, in the initial design stage of the building life cycle, it can fully meet the requirements of green building design. By the end of 2020, there were 874 projects in Shanghai receiving green building labels, with a building area of 80.51 million square meters; A total of 41 green ecological urban areas have been created or sorted and reserved, with a total land area of about 124 square kilometers; Shanghai continuously improves the green building evaluation standards, adopts special support measures, makes building material directory and other regulations, rules and standards; Relying on scientific research subjects to carry out research and develop activities on green buildings in many related fields (SMCHURD, 2021). The Management Measures of Shanghai for Green Buildings issued by Shanghai in 2021 provided legal guarantee for the development of green buildings. The similarity between this text and the Plan is 0.5623, next to Tianjin. The legal texts of

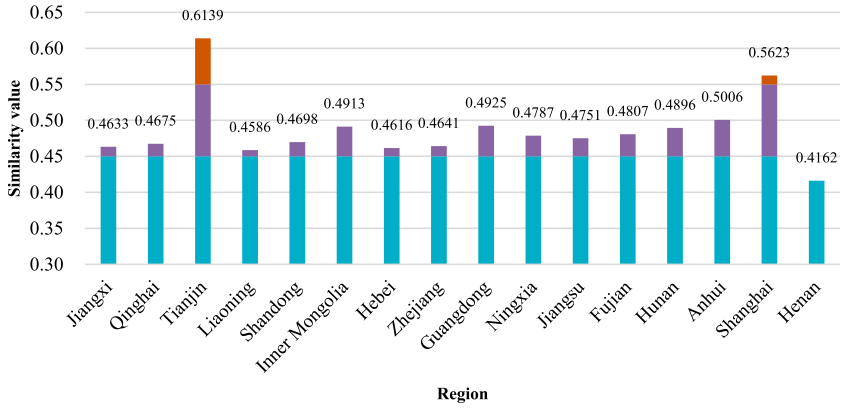

FIGURE 3
Similarity value of legal texts of different regions.

these two cities were formulated before the promulgation of the Plan, but they have such high scores, which shows that local governments have the ability to transform their experiences to legislative innovation, which makes the legal texts have certain policy foresights.

The value of the second level is between .45 and .55, mainly for Jiangxi, Qinghai, Liaoning, Shandong, Inner Mongolia, Hebei, Zhejiang, Guangdong, Ningxia, Jiangsu, Fujian, Hunan and Anhui. These regions are divided into three groups: 1) Jiangsu, Guangdong, Zhejiang and Shandong have made remarkable achievements in green building area, but not reflected in the text analysis (Huang and Gao, 2022); 2) Although Jiangxi, Qinghai and Liaoning issued the legal text very early, and they paid attention to the development of green buildings early, the contents are relatively rough and the characteristic words are scattered, which resulted in low text similarity. Among them, the similarity values of legal texts of Jiangxi and Qinghai are polarized—two of the three major deployments, namely supporting measures and implementation requirements, are extremely low (see Section 4.3.2 for specific analysis), which lower the overall average value; 3) Through the Pkulaw Database, we can find that Inner Mongolia, Hebei, Ningxia, Fujian, Hunan and Anhui have issued many special policies for green buildings, such as green building label management, green building evaluation standards, green building design documents, green building training, green building demonstration projects, expert database list, special inspection of implementation, etc. Some contents are not fully reflected in the provincial legal texts, and therefore the data results are poor. Although these regions were late in releasing their policies, they tend to be later adopters compared to Jiangxi, Qinghai and Liaoning.

The value of the third level is between .4 and .45, and only Henan is in this level. There are two reasons for the low similarity value of Henan Green Building Regulations: First, the characteristic words in the text are scattered, which reduce the score of individual statistical values; Second, the legislation is conservative, lacking the foresightedness shown in the legislation of some other provinces. Most of the new requirements proposed by the Plan do not exist in this sample. Therefore, although the local regulations were issued late, the average similarity score was the lowest. Of course, some other provinces without effective green building regulations, may pay even less attention to green buildings than Henan Province.

4.3.2 Comparison and analysis of the similarities between the three major deployments of the plan and local regulations

Through comparing the indicators similarity of the three major deployments of the Plan and the legal texts of different regions, the differences of the texts among regions could be analyzed, and then the regional characteristics of the development of green buildings could be explored. Results of the data analysis show that the average similarity of the three deployment contents has small difference, but there are large differences between regions.

(1) The average similarity of key tasks in these regions is .4985, which is the highest. As shown in Figure 4, Tianjin is .6631, and is much higher than the average value; Qinghai followed by .5759; Shanghai ranked the third at .5673. These three regions are outstanding in this part, especially Tianjin, which exceeds the second significantly. Tianjin has transformed the experience accumulated in the pilot practice into legal systems, and is the first region to put forward the identification standard of green buildings in China. At present, the construction and application of passive ultra-low energy consumption green buildings in Tianjin are at the forefront of the country (Northern Network, 2022). Shanghai and Tianjin are both municipalities directly

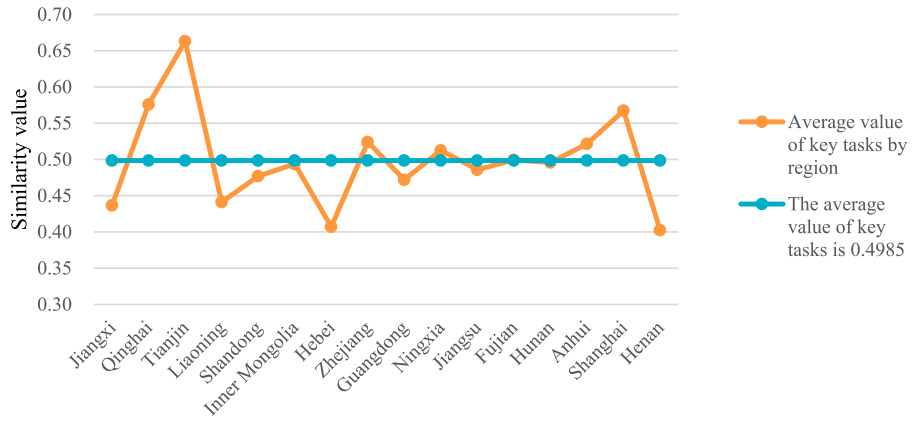

FIGURE 4
Average similarity of key tasks of different regions.

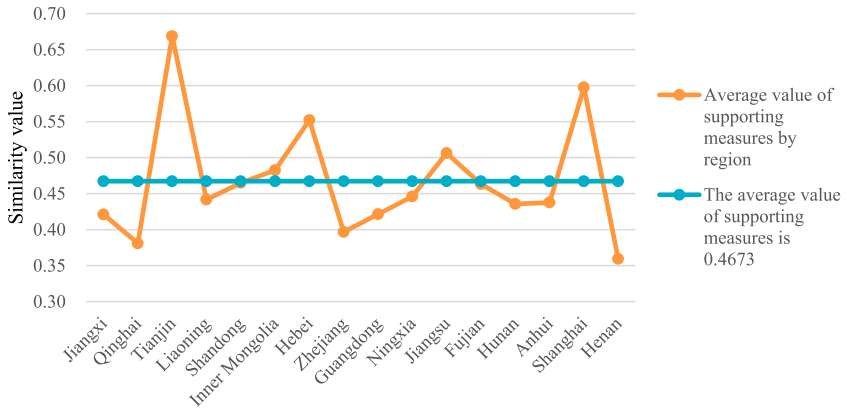

FIGURE 5
Average similarity of supporting measures of different regions.

under the central government, and both are in important geographical locations in China's economic development. Shanghai, like Tianjin, is also outstanding in this part, especially in terms of green construction methods and green building materials. Qinghai's legal text has a high score of similarity in the first part of the key tasks, but it has a relatively low score in the second part of the supporting measures and the third part of the implementation requirements. Looking only at the text of the key tasks of Qinghai Province, it reflects the principle of adapting measures to local conditions and being economically applicable when formulating the legal files. Qinghai has fully considered the climate conditions with small annual precipitation and large regional differences, as well as the natural conditions with rich water resources but outstanding contradiction between supply and demand. In combination with the actual development situation of green buildings, Qinghai is the first province to propose the application of water-saving facilities, rainwater and sewage separation technology, rainwater collection devices, and the use of non-traditional water sources, like rain water, in the 16 analysis texts.

(2) The average similarity of supporting measures in these regions is .4673, which is the lowest. As shown in Figure 5, Tianjin, Shanghai and Hebei are the most prominent regions, with values of .6688, .5976, and .5522 respectively. Tianjin and Shanghai have deployed regulations and standards, incentive policies, system construction, scientific and technological innovation, quality supervision and management measures to ensure the smooth implementation of green building actions. Relying on the rapid economic development, these two

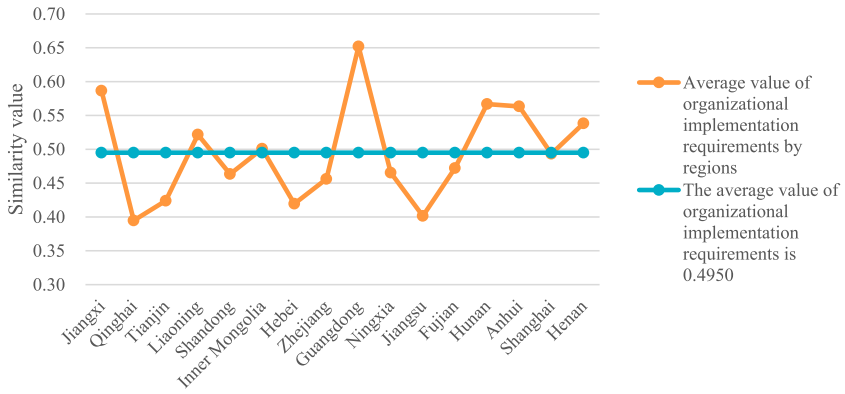

FIGURE 6
Average similarity of implementation requirements of different regions.

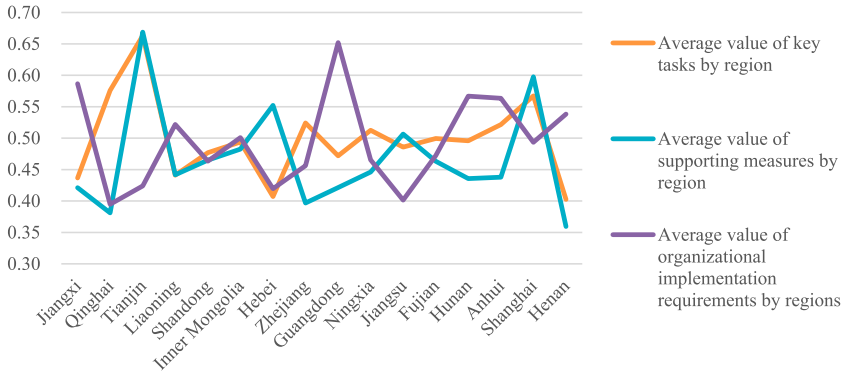

FIGURE 7
Average similarity of three deployment contents of different regions.

regions entered the process of urbanization earlier, so their thinking on urban development and construction is more profound than that of other regions. The text on supporting measures in Hebei Province is also relatively comprehensive, and each item is partially involved.

(3) The average similarity of the implementation requirements of these regions is .4950. As shown in Figure 6, Guangdong and Jiangxi are the most prominent, with values of .6520 and .5867, respectively. The implementation of central policies in local areas is inseparable from organization and implementation. Although Guangdong and Jiangxi scored lower in the first two parts respectively, they scored the highest in this part. The two provinces have specified the arrangement of performance evaluation indicators and the content of publicity channels in details. It is worth mentioning that the Regulations on Green Buildings in Shenzhen Special Economic Zone issued in July 2022 by Shenzhen City, Guangdong Province, put forward higher requirements on the basis of the Regulations on Green Buildings in Guangdong Province. In addition, as a municipal regulation, the Shenzhen Regulation has made many initiatives in China: For the first time, industrial buildings and civil buildings are both included in the scope of legislative adjustment; For the first time, Shenzhen stipulated the carbon emission control objectives in the construction field and the list of key carbon emission buildings in the form of legislation; It is also the first time, that Shenzhen proposed to determine the baseline of energy consumption and carbon emissions for different types of buildings (SMPC, 2022). It can therefore be seen that Guangdong Province has strong organization and leadership as well as efficient policy implementation.

As shown in Figure 7, the superposition of the three-line charts clearly shows that Jiangxi, Qinghai and Guangdong have the largest numerical dispersion and belong to a mode of two low

values and one high value, which means that these three regions are good at playing their roles of governance in a certain aspect, and promoting green building construction with their own advantages, that is, their legal texts highlight the regional characteristics. They either have high score in the organization and implementation, or focus on the adjusting measures to local conditions with high scores on key tasks but have difficulties in implementation.

To sum up, Tianjin and Shanghai have the best comprehensive performances, especially the key tasks and supporting measures; Jiangxi, Qinghai and Guangdong are stronger in showing their regional characteristics in local texts.

5 Conclusion and recommendations

From the perspective of text similarity, this paper conducts a comprehensive comparative study between the three major deployments in the Plan and the legal texts of 16 regions. The results show that all regions pay the highest attention to promoting energy-saving and green transformation of existing public buildings, promoting new green construction methods, and strengthening green building system construction. The highest score was seen in improving the deployment of key tasks. The performances of these regions are different. The legal texts formulated by Tianjin and Shanghai are more complete than those of other provinces, and more in line with the contents of the Plan. Jiangxi, Qinghai and Guangdong each have some outstanding contents, forming regional characteristics according to local conditions. Shandong, Zhejiang, Guangdong and Jiangsu have achieved remarkable results in promoting green buildings, but the legal text fails to reflect the corresponding progress in numerical value.

Based on the above conclusions, as well as the gap between the analyzed texts and the Plan, the legal texts in different regions need to be "patched", and local standards should be used to build a legal guarantee tailored to local conditions. The details are as follows:

(1) All regions should put patch according to the Plan. Taking the content of "Deployment One: Key Tasks of Green Buildings" as an example, carefully sorting out the gaps between the local texts and the Plan, we can get the following items that need to be improved: 1) For the construction task of high-quality green buildings, the Plan mentioned the task content of "government invested public welfare buildings, large public buildings and other new buildings should all be built into star green buildings when conditions permit." Among the 16 texts, 10 regions, Qinghai, Tianjin, Shandong, Zhejiang, Ningxia, Fujian, Hunan, Anhui, Shanghai and Henan, have paid attention to upgrade the construction and operation of new civil buildings, large public buildings and office building for state agencies to the levels of one star or two stars (China's national green building evaluation standard divides green buildings into four levels: basic level, one star level, two star level and three star level) with financial support. But most of the contents of the text are omitted in terms of supervision and management responsibilities, either the supervision and management responsibilities at the construction stage are unclear, or the supervision items in the completion acceptance process do not include meeting the green building operation standard. Therefore, it is recommended that specific provisions should be supplemented in the legal liability chapter to detail the regulatory subject, administrative counterpart and legal consequences in each stage; The evaluation of the issuance of green building labels needs to be extended to a second evaluation after a long period of stable operation of the building, rather than just one time evaluation of the main project upon completion. 2) The task of improving the green building operation management system in the Plan mentioned the establishment of green building user evaluation and feedback mechanism, which is not mentioned in all texts. Therefore, it is recommended that all regions incorporate the user satisfaction survey into the green building operation evaluation, and promote continuous optimization of green building operation level through user evaluation and feedback mechanism. 3) Two contents of the Plan on energy-saving and green transformation of existing public buildings and promotion new green construction methods have been well represented in the texts of different regions. In the future, it is still necessary to closely follow the ever-changing scientific and technological research and development. 4) As for the application and promotion of green building materials in the Plan, except Tianjin, which has achieved remarkable results, other regions should not slack off. Fabricated building structures and prefabricated components with excellent performances are the trend in the future. All regions need to support the R&D of green building materials and supporting technologies. 5) The tasks of green city construction in the Plan are mainly carried out around the low carbon goals. All regions shall formulate comprehensive plan to reduce carbon emissions at all stages of the whole life cycle of green buildings, and to achieve a large-scale promotion from key demonstration projects to urban construction and rural green farmhouse construction. Deployments Two and Three have similar problems, and local regulations need to be sorted out and amended according to the Plan.

(2) Using local standards to construct legal guarantee in accordance with local conditions. China has a vast territory, and the topography, hydrology, water quality, climate, and customs of different regions are quite different. If green building is a high-quality building that realizes the harmonious coexistence of human and nature, then "adaptation to local conditions" should be an important

principle of green building construction, which should be considered in the initial design stage of the whole life cycle of the building. At present, in order to ensure the implementation of green buildings, some regions issue special design requirements in the form of standards, which is used to determine whether the design document meets the green building performance standards. However, most of them are conventional designs that simply apply the "template," which fail to truly reflect the principle of "adaptation to local conditions" (Jungreen.com, 2022). It is undeniable that conventional design is conducive to rapidly improving the quantity of green buildings, but the design based on the principle of "adaptation to local conditions" can better reflect the essence of green buildings—respect for natural conditions, focus on energy-saving and carbon emissions reduction accordingly, such as using solar energy to generate heat in arid areas, collecting rainwater for ecological landscape irrigation, and paying attention to lighting and ventilation in areas where it is rainy all the year round. Taking Tianjin CSTEC as an example, its plan and design respect the local natural conditions, focus on water system recover, wetlands and vegetation ecology, ecological corridor construction, and the formation of an open ecological space (Wang 2009).

In addition, the principle of "adaptation to local conditions" can also be understood as the advantages of government functions, which can be extended to any stage of the whole life cycle of green buildings supervision and management. Therefore, it is recommended that local governments should make proper use of their legislative powers, and establish local standards in accordance with local conditions. This can be learned from the practice of Guangdong Province. Guangdong encourages prefecture level cities to promote local technical standards according to their own actual conditions and specific characteristics. For example, Guangzhou prepared design guidelines such as the Technical Guide for Lingnan Ultra Low Energy Consumption Buildings to strengthen design guidance. Huizhou and Dongguan implemented the key points and guidelines of green building design, construction drawing review and acceptance, to achieve closed-loop management of the whole process (Guangzhou Daily, 2022).

The promotion of green building is a special issue in which the beneficiaries are all people or at least many people, but those who bear the costs are the builders, operators or actual users of the buildings. Large-scale green building construction cannot be carried out spontaneously through market forces, as the transaction costs of reaching consensus are too high, so it must rely on government planning and legal promotion. Both planning and legal rules precede the achievement of green building goals, and for this reason, it is important to study the planning of China's central government and individual local green building regulations. The development of green buildings is a matter that requires the unified promotion of central government with certain goals. The plan at the central level ultimately needs to be refined by local legislation for implementation. Local legislation also needs to be revised based on the latest plan. Text similarity analysis plays an important role in this—it is convenient to observe the differences between central and local policies and law texts, as well as the differences between different regions. This paper selected to compare the Plan text at the front and the local legal texts at the end of the plan and legal structure chain of "central planning—central legislation (currently there is no central level legislation for green buildings)—local planning—local legislation," so as to observe the direction of local regulations modification. Of course, although text similarity analysis can provide a lot valuable analysis points, the inherent shortcomings of word efficiency analysis, such as mainly involving text static comparison and ignoring the dynamic running results of text, cannot achieve 100% accuracy. At the same time, the writing of this paper is limited by the cycle time required for plan development and legislation, and the subsequent comparative analysis can be further carried out after the revision of all the local regulations.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

This research was funded by the National Social Science Foundation of China (Grant no. 18BFX173) and the Delta Environmental Law Young Scholar Award, Delta Group.

Conflict of interest

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

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.1064852/full#supplementary-material

References

Chen, E., and Jiang, E. (2017). Wenben xiangsidu jisuan fangfa yanjiu zongshu [review of studies on text similarity measures]. *Data Analysis Knowl. Discov.* 1 (6), 1. doi:10.11925/infotech.2096-3467.2017.06.01

Chi, B., Lu, W., Ye, M., Bao, Z., and Zhang, X. (2020). Construction waste minimization in green building: A comparative analysis of LEED-NC 2009 certified projects in the us and China. *J. Clean. Prod.* 256, 120749. doi:10.1016/j.jclepro.2020.120749

CTEAC (China-Singapore Tianjin Eco-City Administrative Committee) (2014). China-Singapore Tianjin eco-city has been designated as the "national green building base.Available at: https://www.eco-city.gov.cn/p1/stcxw/20140411/10099.html (Accessed July 15, 2022).

CTEAC (China-Singapore Tianjin Eco-City Administrative Committee) (2018). The Eco-City has set up a green building benchmark. Available at: https://www.eco-city.gov.cn/p1/stcxw/20181121/26726.html (Accessed July 15, 2022).

CTEAC (China-Singapore Tianjin Eco-City Administrative Committee) (2015). The green building industry has set up the "eco-city benchmark. Available at: https://www.eco-city.gov.cn/p1/stcxw/20151125/13558.html (Accessed July 15, 2022).

Ding, Z., Fan, Z., Tam, V. W. Y., Bian, Y., Li, S., Illankoon, I. M. C. S., et al. (2018a). Green building evaluation system implementation. *Build. Environ.* 133, 32–40. doi:10.1016/j.buildenv.2018.02.012

Ding, Z., Li, Z., and Fan, C. (2018b). Building energy savings: Analysis of research trends based on text mining. *Autom. Constr.* 96, 398–410. doi:10.1016/j.autcon.2018.10.008

Doan, D. T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A., and Tookey, J. (2017). A critical comparison of green building rating systems. *Build. Environ.* 123, 243–260. doi:10.1016/j.buildenv.2017.07.007

Franco, M. A. Q., Pawar, P., and Wu, X. (2020). Green building policies in cities: A comparative assessment and analysis. *Energy Build.* 231, 110561. doi:10.1016/j.enbuild.2020.110561

Guangzhou Daily (2022). The newly increased green building area in Guangdong cities and towns accounted for 73% in 2021. Available at: https://baijiahao.baidu.com/s?id=1735889603317409587&wfr=spider&for=pc (Accessed July 17, 2022).

Huang, J., and Gao, X. (2022). *Research report on China's green building market development in 2020*. Beijing: China Construction Industry Press.

Huang, W., and Che, S. (2019). Methodological system and application scenarios on text similarity calculation. *Inf. Stud. Theory & Appl.* 42 (11), 128–134. doi:10.16353/j.cnki.1000-7490.2019.11.021

Hunan Provincial Department of Construction of the PRC (HPDC) (2022). Hunan provincial "fourteenth five year plan" building energy conservation and green building development plan (draft for comments). Available at: http://zjt.hunan.gov.cn/zjt/hdjl/dczj/zjzt/202206/t20220610_25443290.html (Accessed July 15, 2022).

Huo, X., Yu, Ann T. W., and Wu, Z. (2017). A comparative analysis of site planning and design among green building rating tools. *J. Clean. Prod.* 147, 352–359. doi:10.1016/j.jclepro.2017.01.099

Illankoon, I. M., Chethana, S., Tam, V. W. Y., Le, Khoa N., and Shen, L. (2017). Key credit criteria among international green building rating tools. *J. Clean. Prod.* 164, 209–220. doi:10.1016/j.jclepro.2017.06.206

Jiao, L., Wu, F., Luo, F., Zhang, Y., and Huo, X. (2022). Energy and environmental efficiency evaluation of transportation systems in China's 255 cities. *Front. Environ. Sci.* 10, 950562. doi:10.3389/fenvs.2022.950562

Jungreen.com (2022). Promote low-carbon development of green buildings according to local conditions. Available at: https://www.jungreen.com/course/play?id=e1490a48-3078-4ee1-9adb-ae6a010e8a55 (Accessed July 15, 2022).

Li, L., and Li, H. (2018). Computing text similarity based on concept vector space. *Data Analysis Knowl. Discov.* 2 (05), 48–58. doi:10.11925/infotech.2096-3467.2018.0007

Lin, D. (1998). "An information-theoretic definition of similarity," in *Proceedings of the 15th international conference on machine learning*, 296

Liu, G., Tan, Y., and Li, X. (2020). China's policies of building green retrofit: A state-of-the-art overview. *Build. Environ.* 169, 106554. doi:10.1016/j.buildenv.2019.106554

Lu, W., Chi, B., Bao, Z., and Zetkulic, A. (2019). Evaluating the effects of green building on construction waste management: A comparative study of three green building rating systems. *Build. Environ.* 155, 247–256. doi:10.1016/j.buildenv.2019.03.050

Ma, H., and Zhang, T. (2022). Research on the synergy between archives policy and law based on text computing in China: Modeled on archives law of the PRC (2020 revision) and 14th five-year plan for national archives development. *Archives Sci. Study* (02), 26–32. doi:10.16065/j.cnki.issn1002-1620.2022.02.002.04

Mahmood, Q., Qadir, M. A., and Afzal, M. T. (2017). Application of COReS to compute research papers similarity. *IEEE Access* 5, 26124–26134. doi:10.1109/ACCESS.2017.2771207

Maigoo (2022). Previous global green cities in China. Available at: https://www.maigoo.com/goomai/169282.html (Accessed July 16, 2022).

MOHURD (Ministry of Housing and Urban-Rural Development of the PRC) (2019). *Evaluation standard for green buildings (GB/T50378-2019)*. Beijing: Ministry of Housing and Urban-Rural Development.

MOHURD (Ministry of Housing and Urban-Rural Development of the PRC) (2022). *The 14th five-year plan for building energy conservation and green building development*. Beijing: Ministry of Housing and Urban-Rural Development.

MOHURD (Ministry of Housing and Urban-Rural Development of the PRC) (2020). *The notice of the standards and norms department of the Ministry of housing and urban-rural development on carrying out the statistical work of building energy conservation and green building development in 2020*. Beijing: Department of Standards and Quota of the Ministry of Housing and Urban-Rural Development of the PRC.

Northern Network (2022). The construction of passive ultra-low energy consumption green buildings in Tianjin is at the forefront of the country. Available at: http://house.enorth.com.cn/system/2022/08/19/053022032.shtml (Accessed August 21, 2022).

Paraschiv, I. C., Dascalu, M., Trausan-Matu, S., and Philippe, D. (2015). "Analyzing the semantic relatedness of paper abstracts: An application to the educational research field," in *International conference on control systems and computer science* (IEEE), 759–764. doi:10.1109/CSCS.2015.146

Qiang, G. (2020). *Research on Supply and Demand Matching of Green Building Policy-Taking Shaanxi Province as an Example*. (Xi'an, China): Xi'an University of Architecture and Technology. [dissertation/master's thesis].

Santos, R., Costa, A. A., Silvestre, J. D., and Pyl, L. (2019). Informetric analysis and review of literature on the role of BIM in sustainable construction. *Autom. Constr.* 103, 221–234. doi:10.1016/j.autcon.2019.02.022

Shen, L., Yan, H., Fan, H., Wu, Y., and Zhang, Y. (2017). An integrated system of text mining technique and case-based reasoning (TM-CBR) for supporting green building design. *Build. Environ.* 124, 388–401. doi:10.1016/j.buildenv.2017.08.026

SMCHURD (Shanghai Municipal Commission of Housing and Urban-Rural Development of the PRC) (2021). Shanghai: Shanghai municipal commission of housing and urban-rural development." in *Shanghai green building development report 2020*. Available at: https://zjw.sh.gov.cn/jsgl/20211109/7da8fbdc1f11400d8803e0eafd941c6b.html (Accessed July 16, 2022).

SMPC (Shenzhen Municipal People's Congress) (2022). Release and interpretation of the regulations of shenzhen special economic Zone on green buildings. Available at: http://www.szrd.gov.cn/mb/szfg/content/post_821246.html (Accessed July 16, 2022).

Umaroğulları, F., Kartal, S., and Aydın, D. (2020). A comparative study on Turkey's national green building certification system under energy policy developments. *ICONARP Int. J. Archit. Plan.* 8 (1), 187–210. doi:10.15320/ICONARP.2020.110

Wang, C.-L., Yang, Y.-H., Deng, F., and Lai, H.-Y. (2019). Research review of text similarity calculation methods. *Inf. Sci.* (03), 158–168. doi:10.13833/j.issn.1007-7634.2019.03.026

Wang, Q. (2009). An interpretation to Singapore Tianjin eco-city based on sustainable development concept of planning strategies. *Urban Plan. Forum* (02), 102. doi:10.1007/978-3-540-85168-4_52

Wang, Y., Xue, X., Yu, T., and Wang, Y. (2020a). Mapping the dynamics of China's prefabricated building policies from 1956 to 2019: A bibliometric analysis. *Build. Res. Inf.* 49 (2), 216–233. doi:10.1080/09613218.2020.1789444

Wang, Z., Qian, Z., Wang, Z., and Zheng, Y. (2020b). *An analysis of green building design normative documents in Yangtze River Delta area based on content analysis method*. New Architecture, 98–103. doi:10.12069/j.na.202005098

World Green Building Council (2022). What is green building? Available at: https://www.worldgbc.org/what-green-building (Accessed August 25, 2022).

Wu, L. (2020). *Analysis of public emotion on green building based on text Mining*. Wuhan, China: Huazhong University of Science and Technology. [dissertation/master's thesis].

Wu, Z., He, Q., Yang, K., Zhang, J., and Xu, K. (2021). Investigating the dynamics of China's green building policy development from 1986 to 2019. *Int. J. Environ. Res. Public Health* 18, 196. doi:10.3390/ijerph18010196

Wu, Z., Shen, L., Yu, A. T. W., and Zhang, X. (2016). A comparative analysis of waste management requirements between five green building rating systems for new residential buildings. *J. Clean. Prod.* 112, 895–902. doi:10.1016/j.jclepro.2015.05.073

Xu, Y.-Q., and Liu, Y.-Y. (2021). Research and practice on the distance of patent systems between countries based on policy quantification. *J. Xihua Univ. (Philosophy Soc. Sci.* 40 (01), 91–100. doi:10.12189/j.issn.1672-8505.2021.01.009

Yan, Y. (2015). Guihua yu falv de xianjie lujing [Connecting path between planning and law]. *Ziguangge* 2015 (12), 81

Zhang, T., and Ma, H. (2021). Comparative study on artificial intelligence policies in China based on text similarity computation. *J. Intell.* 40 (01), 39. doi:10.3969/j.issn.1002-1965.2021.01.006

Zhang, T., Ma, H., and Yi, Y. (2020). Comparative analysis of China's big data policies from the perspective of text similarity. *Libr. Inf. Serv.* 64 (12), 26–37. doi:10.13266/j.issn.0252-3116.2020.12.004

Zhang, X., Zhan, C., Wang, X., and Li, G. (2019). Asian green building rating tools: A comparative study on scoring methods of quantitative evaluation systems. *J. Clean. Prod.* 218 (MAY 1), 880–895. doi:10.1016/j.jclepro.2019.01.192

Zhang, Y., Chen, X., Mao, Y., Shuai, C., Jiao, L., and Wu, Y. (2021). Analysis of resource allocation and pm2.5 pollution control efficiency: Evidence from 112 Chinese cities. *Ecol. Indic.* 127, 107705. doi:10.1016/j.ecolind.2021.107705

Zhang, Y., Kang, J., Jin, H., and Zhang, Y. (2022). Influencing factors of the development of green building by designers based on grounded theory. *Int. J. Struct. Civ. Eng. Res.* 11 (2), 35–41. doi:10.18178/ijscer.11.2.35-41

Zhao, S., and Chen, L. (2020). The influencing factors and mechanism of green housing purchase intention - based on the grounded theory perspective. *Enterp. Econ.* (04), 28–36. doi:10.13529/j.cnki.enterprise.economy.2020.04.004

Zhao, X., Zuo, J., Wu, G., and Huang, C. (2019). A bibliometric review of green building research 2000-2016. *Archit. Sci. Rev.* 62 (1), 74–88. doi:10.1080/00038628.2018.1485548