Determination of the Weight of Urban Resilience Evaluation Index from the Perspective of Disaster Prevention

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Abstract

With the rapid development of economy, the city is facing the problems arise, suffering from the disasters, in the process of urban rapid development, because the city more and more complex structure, but also produced many unstable factors, extreme weather are increasingly frequent and violent past traditional disaster prevention plan and measures are not practical, not enough to cope with today's disaster risk, Improving urban resilience is urgent. Based on the evaluation of urban resilience from the perspective of disaster prevention, this paper constructs the evaluation system of urban resilience from the following five aspects: In addition, the actual data of the resilience evaluation indexes of Tangshan city were applied to determine the weight of each index by ahp and entropy method, providing theoretical significance for the study of urban resilience.

Keywords

City toughness; Analytic hierarchy process; Entropy value method; The weight.

1. Introduction

In recent years, the continuous deepening of China's urbanization, the rapid development of science and technology, and the sharp increase in energy consumption have brought about the greenhouse effect. Global warming has also greatly increased the probability of many extreme weather and disasters. Cities are facing increasingly complex unknown natural disasters, such as the snow disaster in Yushu, Qinghai province in 2016, torrential rain and flooding in five provinces in the middle and lower reaches of the Yangtze River in 2017, hail disaster in Sichuan and Guizhou in 2018, massive landslide in Shuicheng, Guizhou in 2019, COVID-19 in 2020, and torrential rain and flood in Henan in 2021, which caused heavy losses in China. Seriously affect the development of China's cities. How to improve the ability of cities to deal with disasters and the resilience of cities has become the focus of scholars' research.

2. The Research Background

Foreign scholars' studies on urban resilience are as follows: Seyedmohsen Hosseini et al. elaborated and summarized the meaning of resilience from four aspects of organization, society, economy and engineering. They believed that resilience focuses on the ability of the system to "absorb"and "adapt" to destructive events, referring to disaster preparedness activities, and "recovery" is the key content of resilience. However, the mechanism for achieving resilience is still not specified [1]. Zhang Huiming et al. constructed a comprehensive evaluation model using entropy-weighted TOPSIS method from social, environmental, economic and management aspects, improved the index system of urban flood resistance, and evaluated the flood resistance capacity of 31 key flood control cities in China [2]. Parsons Melissa et al. used the

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disaster resilience index conceptual model from three levels to conduct a nationwide assessment of Australia's resilience, overall capacity of disaster resilience, coping and adaptation capacity, as well as eight disaster resilience themes in social, economic and institutional fields. It points out a new direction for the establishment of disaster prevention city model [3]. Tariq Hisham et al. conducted an in-depth analysis of 36 resilience frameworks, examining whether assessment frameworks used subjective or objective methods to define and measure resilience, what data collection methods they used, what data the assessment relied on, and what dimensions were included in the measurement process. To help develop a suitable method for measuring resilience [4]. Yi Fangxin et al. developed a six-attribute resilience framework based on attributes from the perspective of disaster resistance to evaluate the post-disaster management and construction of Yushu on the Qinghai-Tibet Plateau and put forward corresponding suggestions. It provides a good model for resilience assessment of disaster-resistant cities [5]. Sajjad Muhammad used frequency distribution and difference analysis (ANOVA) to analyze the differences between different resilience indices in three dimensions: economic, institutional and social, and conducted cross-regional assessments at the subnational level. Extensive spatial assessments were also carried out using geographic information models to explore global and local areas of resilience [6].

However, domestic scholars' research on urban resilience is later than that of foreign countries, and the theoretical research is relatively immature. Zang Xinyu et al. summarized the concept of urban resilience and made a specific analysis of the research content. Literature analysis was used to detail the concept and definition of urban resilience, and summarized the characteristics of urban resilience research in China, indicating that the development trend should pay more attention to systematic, timeliness and institutional research [7]. Guo Xiaodong et al. studied the meaning of resilient city from three aspects: disaster reduction, adaptation and post-disaster recovery. The quantitative methods for evaluating urban disaster prevention and resilience are studied and the concrete schemes for improving urban resilience are put forward. [8]. By combining empirical analysis and expert interviews, five first-level resilience evaluation indicators, including situational cognition, disaster resistance and social capital, and 18 second-level resilience evaluation indicators were selected to jointly construct an evaluation system for community resilience, and corresponding countermeasures and suggestions were put forward for the shortcomings in the construction of community resilience in China [9]. Zhou Qingwei summarized the existing urban resilience evaluation system and selected some evaluation indexes. The subjective index research method is used to select the evaluation index. Finally, several analytical methods such as analytic hierarchy process (AHP) and Delphi method were investigated to further revise the evaluation index. After the establishment of the final evaluation system, an empirical test was carried out [10]. Chen Changkun et al. constructed an evaluation model based on TOPSIS (Approximate ideal solution ranking method) of 3 first-level indicators and 25 second-level indicators based on the three major attributes of urban resilience: resistance, resilience and adaptability. [11]. From the qualitative perspective, Shi Yuan et al. established evaluation indicators of community disaster prevention and resilience based on the principle of index selection and five levels including organization, society, economy, society and facilities. [12]. Xu Zhaofeng et al. classified the indicators according to the four aspects of infrastructure, economy, organization/system and society, and constructed an evaluation index system of urban disaster resilience, determined the weights through analytic hierarchy process, and constructed a comprehensive evaluation model of urban disaster resilience by using cloud matter-element method to evaluate the disaster prevention and resilience of the city [13]. The above studies are still lacking in the construction of urban resilience system, and few literatures have carried out empirical studies on the determination method of urban resilience index weight.

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Based on the literature, it can be seen that economic, social, ecological and infrastructure are the mainstream models of urban resilience in the evaluation index classification of criterion level. Infrastructure, as the lifeline system of cities, is the foundation and prerequisite for building resilient cities. Economic development is the top priority of national survival and development, and the operation capacity of economic system is particularly important when disasters occur. As a human-oriented country, the resilience of the city is reflected by the ability of social groups to cope with and cooperate with risk factors from the perspective of society, so the improvement of the overall quality of the citizens is of great significance for the development of the city. The better the ecological environment, the higher the coverage rate of urban green space is conducive to flood control, effectively reduce the severity of disasters, conducive to post-disaster reconstruction. However, in the aspect of urban resilience, just like the large-scale OUTBREAK of COVID-19, the timely emergency measures taken by the government to the city and the control of epidemic prevention and control in all aspects of the city still play an important role. Institutions are the cornerstone of national governance and an important foundation of the national governance system, reflecting the governance capacity of local governments. Especially in the face of disasters to play a variety of organizational management capabilities.

Therefore, this paper divides urban resilience into five aspects: infrastructure, economy, society, institution and ecology.

3. Establishment of Urban Resilience Index System

In this paper, the evaluation system of urban resilience is divided into five modules: infrastructure, economy, society, institution and ecology. However, infrastructure resilience can be divided into several representative aspects, such as urban lifeline facilities, transportation facilities and special facilities. Economic resilience can be divided into economic stability and economic diversification; Social resilience can be divided into social capacity and public service; Institutional resilience can be divided into prevention before disaster, response during disaster and learning after disaster. Ecological resilience can be divided into three sub-criteria: disaster risk, resource protection and sustainable development. Further research is conducted on each aspect and more representative indicators are selected, as shown in Table 1.

4. Determination Method of Urban Resilience Evaluation Index Weight

In this paper, the evaluation index of urban resilience is determined by using AHP method and entropy method respectively through formula calculation, and the index weight of each level is obtained successively, and then the results of the two methods are combined to make the results more scientific.

4.1. Analytic Hierarchy Process

(1) Establishment of hierarchical structure model

When using the analytic hierarchy process to analyze the problem, we should first decompose the decision-making problem in order and hierarchically, and build the logical relationship of successive layers. The hierarchy is divided into objective layer, criterion layer and scheme layer. In this paper, the evaluation of urban resilience is taken as the objective layer, and there are criterion layer, sub-criterion layer and scheme layer successively.

(2) Construct the judgment matrix

Toughness evaluation system based on certain city, for the purpose of comparison criterion layer of the importance of each criterion, this paper is to put the infrastructure, economic, social, and ecological resilience as indicators of five grade two, in the same way the rest of the

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indicators at all levels should also compare two similar, comparative methods using "1-9 scaling method", a judgment matrix such as formula (1). If A is the criterion layer, the element of A layer is A_k . A_k has a factor of its next layer,B. B_i influencing factors, b_{ij} is the ratio of B_i and B_j , forming the judgment matrix P= $\left(b_{ij}\right)_{n\times n}$.

Table 1. Evaluation index system

The target layer	Rule layer	Index layer	Index attribute
Evaluation index system of toughness	A.Infrastructure resilience	Heating system -- heating conditions.A_1	+
		Power supply capability: Power supply reliability.A_2	+
		Water supply systems - Water supply coverage.A_3	+
		Gas supply system - gas penetration.A_4	+
		Communication system - Communication signal stability.A_5	+
		Seismic capacity - seismic capacity of buildings.A_6	+
		Fire prevention ability.A_7	+
		Flood control ability.A_8	+
		Traffic flow condition.A_9	+
		Safety rationality of evacuation route.A_{10}	+
		Specification of emergency shelters.A_{11}	+
		Shelter area per capita.A_{12}	+
	B.Economic resilience	Home ownership.B_1	+
		The employment rate.B_2	+
		Per capita income level.B_3	+
		The enterprise scale.B_4	+
		Diversification of industrial distribution.B_5	+
	C.Social resilience	Ability to cope with risk.C_1	+
		Ability to communicate.C_2	+
		Social insurance coverage.C_3	+
		Education Level.C_4	+
		Mental health assistance.C_5	+
	D.System of toughness	Preparation of emergency supplies.D_1	+
		The completeness of disaster preparedness plans.D_2	+
		The popularization of disaster prevention and mitigation knowledge education.D_3	+
		Construction quality of urban disaster prevention management personnel.D_4	+
		The extent to which professional rescue teams have been built.D_5	+
		Publicity of disaster prevention and mitigation.D_6	+
		Disaster information management and processing.D_7	+
		On-site command of disaster relief ability.D_8	+
		Speed of response of emergency mechanism.D_9	+
		Ability to learn after a disaster.D_{10}	+
	E.Ecological resilience	The extent of the damage.E_1	—
		Green coverage.E_2	+
		Sewage treatment rate.E_3	+
		System resistance stability.E_4	+
		Ability to reorganize and recover after disaster.E_5	+
		Percentage of energy available (KWH per unit of energy).E_6	+

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$$P=\left(b_{ij}\right)_{n\times n}=\begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b \\ \vdots & \vdots & \vdots & \vdots \\ b_{n1} & b_{n2} & \cdots & b_{nn} \end{bmatrix} \tag{1}$$

The specific meaning of judgment matrix is shown in Table 2.

Table 2. Scale and meaning of judgment matrix

Scale	Comparison of factors indicates meaning
1	The two factors are equally important
3	Factor 1 is slightly more important than factor 2
5	Factor 1 is more important than factor 2
7	Factor 1 is more important than factor 2
9	Factor 1 is more important than factor 2
2, 4, 6, 8	Represents the importance between the two adjacent scales
The reciprocal of 1 ~ 9	If the importance scale of factor I and factor J is a_{ij}, the importance ratio of factor J to factor I is $a_{ji}=1/a_{ij}$.

(3) Determine the weight of each indicator

Select jiheping method to calculate index weight:

① New vector M_i is obtained by row multiplication in judgment matrix P

$$M_i=\prod_{j=1}^{n} b_{ij}\ , i=1,2,\ldots,n \tag{2}$$

②Take the NTH root of every component vector of M_i

$$W_i^{'}=\sqrt[n]{M_i}\ , i=1,2,\ldots,n \tag{3}$$

③ Normalize vector M_i

$$W_i=W'/\sum_{i=1}^{n}W' \tag{4}$$

(4) Hierarchical sorting and consistency test

The results are arranged in order according to the importance of weights. This part also needs to conduct consistency test to ensure the accuracy of the results.

① Calculate consistency indicators

$$CI=\frac{\lambda_{\max}-n}{n-1} \tag{5}$$

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Where, λ_{max} represents the maximum eigenvalue of the matrix, and n represents the order of the judgment matrix.

$$\lambda_{max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(PW)_i}{nW_i} \tag{6}$$

Where $(PW)_i$ represents the ith factor of vector PW.

② Calculate the consistency ratio CR

$$CR = \frac{CI}{RI} \tag{7}$$

Where, RI is the average random consistency indicator, as shown in Table 3. Consistency judgment basis:

When CR=0, it is exactly the same;

When CR<0.1,the consistency is considered within the permissible range;

When CR≥0.1,the judgment matrix needs to be adjusted.

Table 3. Average random consistency index values

The matrix order:n	1	2	3	4	5	6	7	8	9	10	11	12
RI	1	0	0.52	0.89	1.12	1.26	1.36	1.41	1.52	1.54	1.56	1.58

4.2. Entropy Value Method

Entropy method is mainly used to calculate the weight of other indicators through the size of entropy. According to information theory, the order degree of a system is expressed by entropy value, which can reflect the order level of the system and is negatively correlated with it. The steps of comprehensive evaluation by entropy method are as follows:

(1) Establish a judgment matrix of M evaluation levels and N evaluation indicators:

$$X = (x_{ij})_{m\times n}, (i = 1,2,\ldots,n; j = 1,2,\ldots,m) \tag{8}$$

(2) Standardizing the data by eliminating the difference between positive and negative orientations of different indicators and different measures:

Positive indicators:

$$x_{ij}' = \frac{x_{ij} - x_{j\min}}{x_{j\max} - x_{j\min}} \tag{9}$$

Reverse index:

$$x_{ij}' = \frac{x_{j\max} - x_{ij}}{x_{j\max} - x_{j\min}} \tag{10}$$

Where i=1,2,...,n; j=1,2,...,m

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(3) Under item J index, the proportion of the ith grade in item J index p_{ij} :

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{11}$$

(4) Calculate the entropy value of the JTH index e_j :

$$e_j = -k \sum_{i=1}^{m} p_{ij} \ln p_{ij} \tag{12}$$

Where, $k > 0$, $e_j \geq 0$. If j is given, and X_{ij} is the same, then $p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} = \frac{1}{m}$, e_j is going to be the maximum, so that means that

$$e_j = -k \sum_{i=1}^{m} \frac{1}{m} \ln \frac{1}{m} = k \ln m \tag{13}$$

When $k = \frac{1}{\ln m}$, then $0 \leq e_j \leq 1$.

(5) Calculate the difference coefficient g_j of item J:

For the JTH index, the degree of difference of the matrix is negatively correlated with e_j, so g_j can be used as the coefficient of difference to represent the degree of difference of the data. In other words, the greater the degree of difference between each indicator, the higher the value of this indicator for this study.

(6) Weight calculation:

$$w_j = \frac{g_j}{\sum_{j=1}^{m} g_j} \tag{15}$$

4.3. Comprehensive Weight Calculation

Subjective and objective comprehensive empowerment method is one of the joint more balanced with subjective and objective weighting comprehensive calculation method, this method not only eliminates the evaluators for importance evaluation is too subjective, also breaks for data values too objectively reflected, but has not responded for the degree of subjective important decision makers in the index, improve the accuracy of the results. This paper is based on the combination of subjective weight and objective weight weighting method, as a balance of subjective and objective state, to achieve the internal unity of subjective and objective evaluation.

The comprehensive weight calculation of indicators is carried out according to the following formula:

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$$W_j = \frac{\sqrt{\alpha_j \beta_j}}{\sum_{j=1}^{n} \sqrt{\alpha_j \beta_j}} \tag{16}$$

Where, α_j is the final weight calculated by analytic hierarchy process, and β_j is the final weight calculated by entropy method.

5. Case Analysis

Tangshan city in Hebei Province is taken as the example to verify this study. Firstly, questionnaires are issued to university experts in disaster prevention management, disaster prevention consulting units and emergency management bureau, and subjective analytic hierarchy process is used to score and summarize and score again by relevant experts. Finally, relevant quantitative data are obtained. Then by searching "Tangshan Statistical Yearbook", "Hebei Statistical Yearbook", statistics bureau statistics and other relevant data to obtain the actual data of the corresponding index to determine the weight.

5.1. Ahp Determines the Weight

Because the level is more, in this paper, we construct evaluation system index number is various, the process of the complex calculation and inspection, the hand is easy to appear the phenomenon of calculation error, so this article by the expert scoring method used in tangshan toughness index score, using analytic hierarchy process YAAHP software to assist in computing model, can be efficient and fast accurate weights and test them.

(1) Determine the weight of first-level evaluation indicators

Table 4. Hierarchical analysis results of first-level indicators

Toughness evaluation	A	B	C	D	E	w_i
A	1	2	3	1	2	0.2909
B	1/2	1	3	1/2	3	0.2170
C	1/3	1/3	1	1/2	2	0.1214
D	1	2	2	1	2	0.2698
E	1/2	1/3	1/2	1/2	1	0.1009

According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =5.266,corresponding weight vector w_i is, in turn: [0.2909,0.2170,0.1214,0.2698,0.1009].Since $CR = \frac{CI}{RI}$ =0.0594<0.1, it meets the requirement of consistency test.

(2) Determine the weight of secondary evaluation indicators

① Resilience of infrastructure

Table 5. Hierarchical analysis results of second-level indicators

A	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	w_i
A_1	1	1/3	1/3	1/2	2	1/2	2	2	2	2	2	2	0.0238
A_2	3	1	2	3	3	2	3	3	4	3	3	3	0.0542
A_3	3	1/2	1	2	3	2	3	3	4	3	3	2	0.0454
A_4	2	1/3	1/2	1	1/2	1/2	2	2	1/2	1	2	2	0.0215
A_5	1/2	1/3	1/3	2	1	1/2	2	1	2	2	2	2	0.0224
A_6	2	1/2	1/2	2	2	1	2	2	3	3	3	2	0.0338
A_7	1/2	1/3	1/3	1/2	1/2	1/2	1	1	1/2	2	2	2	0.0161
A_8	1/2	1/3	1/3	1/2	1	1/2	1	1	1/2	2	2	2	0.0169
A_9	1/2	1/4	1/4	2	1/2	1/3	2	2	1	2	2	2	0.0205
A_{10}	1/2	1/3	1/3	1	1/2	1/3	1/2	1/2	1/2	1	1	1/2	0.0114
A_{11}	1/2	1/3	1/3	1/2	1/2	1/3	1/2	1/2	1/2	1	1	1/2	0.0106
A_{12}	1/2	1/3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	2	2	1	0.0142

According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =12.7775,corresponding weight vector w_i is, in turn: [0.0238,0.0542,0.0454,0.0215,0.0224,0.0338,0.0161,0.0169,0.0205,0.0114,0.0106,0.0142]. $CR=\frac{CI}{RI}$ =0.0459<0.1, it meets the requirement of consistency test.

② Economic resilience

Table 6. Hierarchical analysis results of secondary indicators

B	B_1	B_2	B_3	B_4	B_5	w_i
B_1	1	1/2	1/2	1	1/2	0.0257
B_2	2	1	2	3	1/2	0.0578
B_3	2	1/2	1	2	1/2	0.0401
B_4	1	1/3	1/2	1	1	0.0302
B_5	2	2	2	1	1	0.0632

According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =5.3264,corresponding weight vector w_i is, in turn: [0.0257,0.0578,0.0401,0.0302,0.0632]. $CR=\frac{CI}{RI}$ =0.0459<0.1,it meets the requirement of consistency test.

③ Social resilience

Table 7. Hierarchical analysis results of secondary indicators

C	C_1	C_2	C_3	C_4	C_5	w_i
C_1	1	3	1/2	1/2	3	0.0269
C_2	1/3	1	1/2	1/2	2	0.0159
C_3	2	2	1	2	2	0.0380
C_4	2	2	1/2	1	2	0.0286
C_5	1/3	1/2	1/2	1/2	1	0.0120

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According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =5.3176, corresponding weight vector w_i is, in turn: [0.0269,0.0159,0.0380,0.0286,0.0120]. $CR=\frac{CI}{RI}$ =0.0709<0.1,it meets the requirement of consistency test.

(4) Institutional resilience

Table 8. Hierarchical analysis results of second-level indicators

D	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	w_i
D_1	1	2	3	3	3	3	2	2	2	3	0.0543
D_2	1/2	1	2	3	3	2	1	1	1	2	0.0345
D_3	1/3	1/2	1	1/2	1/2	1	1/2	1/3	1/3	2	0.0145
D_4	1/3	1/3	2	1	2	2	1/2	1/2	1/2	2	0.0214
D_5	1/3	1/3	2	1/2	1	2	1/2	1/2	1/2	2	0.0188
D_6	1/3	1/2	1	1/2	1/2	1	1/2	1/2	1/2	2	0.0156
D_7	1/2	1	2	2	2	2	1	1/2	1	2	0.0292
D_8	1/2	1	3	2	2	2	2	1	2	2	0.0381
D_9	1/2	1	3	2	2	2	1	1/2	1	2	0.0306
D_{10}	1/3	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1	0.0128

According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =10.4172,corresponding weight vector w_i is, in turn: [0.0543,0.0345,0.0145,0.0214,0.0188,0.0156,0.0292,0.0381,0.0306,0.0128]. $CR=\frac{CI}{RI}$ =0.2698<0.1,it meets the requirement of consistency test.

⑤ Ecological resilience

Table 9. Hierarchical analysis results of second-level indicators

E	E_1	E_2	E_3	E_4	E_5	E_6	w_i
E_1	1	2	2	1/2	1/2	1/2	0.0148
E_2	1/2	1	1/2	1/2	1/2	2	0.0120
E_3	1/2	2	1	1/2	1/2	1	0.0127
E_4	2	2	2	1	1	2	0.0241
E_5	2	2	2	1	1	2	0.0241
E_6	2	1/2	1	1/2	1/2	1	0.0132

According to the calculation of the judgment matrix above, the maximum eigenvalue of the matrix is $\lambda_{\max}$ =6.4015,corresponding weight vector w_i is, in turn: [0.0148,0.0120,0.0127,0.0241,0.0241,0.0132]. $CR=\frac{CI}{RI}$ =0.0637<0.1,it meets the requirement of consistency test.

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5.2. Entropy Method to Determine the Weight

According to the calculation formula mentioned above, tangshan statistical yearbook and other relevant data were introduced to calculate the objective weight value of first-level index and second-level index of urban resilience evaluation from the perspective of disaster prevention by using MATLAB software. The weight coefficient W is obtained by calculating the information entropy value e and the difference coefficient G of each index. The calculation results are shown in the table below.

(1) The weight of first-level indicators

Table 10. Entropy results of first-level indicators

Toughness evaluation	e	g	w
A	0.9455	0.0545	0.1471
B	0.8541	0.1459	0.3941
C	0.8997	0.1003	0.2709
D	0.9630	0.0370	0.1000
E	0.9675	0.0325	0.0878

(2) Weight of secondary index layer

Table 11. Entropy results of second-level indicators

A	e	g	w
A_1	0.8836	0.1164	0.1318
A_2	0.9658	0.0342	0.0387
A_3	0.8994	0.1006	0.1138
A_4	0.9184	0.0816	0.0923
A_5	0.8944	0.1056	0.1196
A_6	0.9024	0.0976	0.1105
A_7	0.9378	0.0622	0.0705
A_8	0.9328	0.0672	0.0761
A_9	0.8655	0.1345	0.1522
A_{10}	0.9737	0.0263	0.0298
A_{11}	0.9800	0.0200	0.0226
A_{12}	0.9628	0.0372	0.0421

Table 12. Entropy results of second-level indicators

B	e	g	w
B_1	0.9690	0.0310	0.0821
B_2	0.8642	0.1358	0.3597
B_3	0.8979	0.1021	0.2704
B_4	0.9284	0.0716	0.1897
B_5	0.9630	0.0370	0.0981

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Table 13. Entropy results of second-level indicators

C	e	g	w
C_1	0.8541	0.1459	0.3554
C_2	0.9114	0.0886	0.2157
C_3	0.9697	0.0303	0.0737
C_4	0.8867	0.1133	0.2760
C_5	0.9675	0.0325	0.0792

Table 14. Entropy results of second-level indicators

D	e	g	w
D_1	0.9684	0.0316	0.0543
D_2	0.9326	0.0674	0.1159
D_3	0.9540	0.0460	0.0790
D_4	0.9050	0.0950	0.1634
D_5	0.9254	0.0746	0.1282
D_6	0.9634	0.0366	0.0629
D_7	0.9302	0.0698	0.1200
D_8	0.9280	0.0720	0.1237
D_9	0.9226	0.0774	0.1331
D_{10}	0.9886	0.0114	0.0195

Table 15. Entropy results of second-level indicators

E	e	g	w
E_1	0.9188	0.0812	0.2639
E_2	0.9511	0.0489	0.1590
E_3	0.9441	0.0559	0.1817
E_4	0.9671	0.0329	0.1068
E_5	0.9671	0.0329	0.1068
E_6	0.9441	0.0559	0.1817

5.3. Comprehensive weight determination

Through the calculation of the subjective and objective combination weighting method based on the above formula, the weight results of each index combination of the first-level index layer and the second-level index layer can be obtained in the following table.

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Table 16. Weighting results of combination of first-level indicator layers (toughness evaluation)

Toughness evaluation	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
A	0.2909	0.1471	0.2203
B	0.2170	0.3941	0.3114
C	0.1214	0.2709	0.1931
D	0.2698	0.1000	0.1749
E	0.1009	0.0878	0.1002

Table 17. Weighting results of the combination of secondary indicator layers (infrastructure resilience)

A	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
A_1	0.0238	0.1318	0.1088
A_2	0.0542	0.0387	0.0890
A_3	0.0454	0.1138	0.1396
A_4	0.0215	0.0923	0.0865
A_5	0.0224	0.1196	0.1005
A_6	0.0338	0.1105	0.1187
A_7	0.0161	0.0705	0.0654
A_8	0.0169	0.0761	0.0697
A_9	0.0205	0.1522	0.1085
A_{10}	0.0114	0.0298	0.0358
A_{11}	0.0106	0.0226	0.0301
A_{12}	0.0142	0.0421	0.0475

Table 18. Weighting results of the combination of secondary indicator layers (economic resilience)

B	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
B_1	0.0257	0.0821	0.1024
B_2	0.0578	0.3597	0.3214
B_3	0.0401	0.2704	0.2321
B_4	0.0302	0.1897	0.1687
B_5	0.0632	0.0981	0.1755

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Table 19. Weighting results of the combination of secondary indicator layers (social resilience)

C	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
C_1	0.0269	0.3554	0.2973
C_2	0.0159	0.2157	0.1780
C_3	0.0380	0.0737	0.1609
C_4	0.0286	0.2760	0.2701
C_5	0.0120	0.0792	0.0937

Table 20. Weighting results of the combination of secondary indicator layers (institutional resilience)

D	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
D_1	0.0543	0.0543	0.1089
D_2	0.0345	0.1159	0.1269
D_3	0.0145	0.0790	0.0679
D_4	0.0214	0.1634	0.1186
D_5	0.0188	0.1282	0.0985
D_6	0.0156	0.0629	0.0629
D_7	0.0292	0.1200	0.1188
D_8	0.0381	0.1237	0.1377
D_9	0.0306	0.1331	0.1280
D_{10}	0.0128	0.0195	0.0317

Table 21. Weighting results of the combination of secondary indicator layers (ecological resilience)

E	Analytic hierarchy Process weight w_1	Entropy method weight w_2	The combination weightsW
E_1	0.0148	0.2639	0.2051
E_2	0.0120	0.1590	0.1434
E_3	0.0127	0.1817	0.1577
E_4	0.0241	0.1068	0.1665
E_5	0.0241	0.1068	0.1665
E_6	0.0132	0.1817	0.1608

6. Results Analysis

By combining analytic hierarchy process (ahp) and entropy value method of joint application, make a more scientific and effective weight, the weight of the economy of the city can see toughness is 0.3114, the largest proportion, and to prove the tangshan is a economy is relatively developed city, is a center of Beijing and tianjin tang industrial base city, is the second most important infrastructure, the second is social, and ecological system. Social and institutional aspects, we should improve the planning of disaster prevention, formulate a more thorough plan, nip in the wind, vigorously invest in the construction of disaster prevention team. Weights of ecological resilience is too low, can be seen in the development of heavy industry at the same time, ignore the importance of environmental protection, in improving of economic construction at the same time, more should pay attention to the environment protection, reasonable planting green plants, improve the greening coverage, increase the complexity of the ecological environment, improve the environment resistance and resilience, etc.

7. Summary

This article through the literature research selected the five first-level indicators, 38 secondary indexes, based on the perspective of disaster prevention construct evaluation system of urban resilience, and through the introduction of the related data of tangshan, in analytic hierarchy process (ahp) and entropy value method, on the basis of comprehensive empowerment will be quantitative evaluation index for the specific data, determine the weight of each index, avoid evaluation is too subjective, It also effectively shows the actual authority of objective indicators and shows the weight of urban resilience from five aspects. Due to the wide range of urban resilience evaluation fields, the selected indicators still need to be further improved, and the evaluation methods also need to be improved.

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