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# Contents

**Analysis of Livable City Evaluation Model based on Mathematical Method**  
Teng Rong, Yuhang Dong.....(1)

**Comprehensive Application of Multidimensional Color in Graphic Design**  
Shu Li.....(5)

**Cost Planning and Scale Analysis of Colleges and Universities based on Statistical Modeling**  
Genxiong Wu, Dai Hu, Shuangshuang Zhou.....(8)

**Brief Analysis on the Application of One-Card System in Intelligent Campus**  
Shuaili Wang.....(13)

**The Analysis of generalized SFA**  
Min Wang.....(16)

**Application of Computer Room Management in Cloud Computing**  
Jianjun Wu.....(23)

**A New Non-monotone Adaptive Retrospective Trust Region Method for Unconstrained Optimization Problems**  
Yajing Wang.....(26)

**Adaptive Cubic Regularization Methods for Solving Non-convex Multi-objective Optimization Problem**  
Huanhuan Yang.....(30)

**An Improved Inexact Newton Method for Nonlinear Equations**  
Meihong Zhou.....(34)

**On the Development and Application of Electronic Commerce**  
Yuhao Kang, Hean Liu.....(39)

**Research on Training Recruitment Mode based on School Enterprise Cooperation**  
Feng Li, Jinya Sun, Hean Liu.....(42)

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# Analysis of Livable City Evaluation Model based on Mathematical Method

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**Abstract:** Based on the evaluation of livable cities, this paper selects several representative indicators for evaluating livable cities, and evaluates livable cities by establishing evaluation models for livable cities, and makes recommendations. For the evaluation index of China's existing livable cities, based on the rationality of the indicators in the literature, the principal component analysis method was used to establish a mathematical model for evaluating livable cities. According to the data of the past five years of collecting the main indicators of the eight major cities, the rationality analysis of these data gives a ranking of livable cities. Then the relationship between uncertain factors and indicators is established. Through the relationship between uncertain factors and indicators, the influence of uncertain factors on livable cities is obtained. Finally, taking Xuzhou as an example, further analyze the livable city in Xuzhou City, and give targeted suggestions for further improving the livability level of the city.

**Keywords:** Livable City; Analytic hierarchy process; Principal component analysis; Nonlinear iterative method

## 1. Introduction

"Livable City" is the trend and direction of urban development in today's world. It is the highest realm of urban construction, representing the new urban ideal and conforming to the central concept of "scientific development" and "harmonious society". After the State Council document first proposed the concept of "livable city" in January 2005, more than 200 cities across the country have identified "livable cities" as development goals. "Livability" is the city's first attribute and basic attribute. Any city with human habitation has certain livability. Urban livability is one of the hot topics in the current urban scientific research field, and it is also the focus of close attention of the government and urban residents. Building a livable city has become an important goal of China's urban development at this stage. It is of great significance to improving the quality of life of urban residents, improving urban functions and improving the efficiency of urban operations.

## 2. Design Analysis of Livable City Evaluation System

A livable city is a complex establishment process. In accordance with the connotation of a livable city, in the evaluation process of a livable city, consider the following aspects:

1. Economic development. Economic development not only means the expansion of the national economy, but also the improvement of the quality of life in the econo-

my and society. 2. Social harmony. Social harmony depends to a large extent on factors that are not directly related to the economy, reflecting people's self-evaluation and expectations about their health, living conditions and quality of quality in livable cities. 3. Cultural richness. It includes the code of conduct, ethics, traditional customs, value pursuit and lifestyle that the members of the society follow together. It represents the taste and character of a city and is the soul of the city. 4. Urban environmental conditions. To evaluate whether a city is livable, it should first be measured by its impact on the whole city. If you do not consider this factor, it will lead to the fragmentation of the urban macro environment, and the livability is passive water.

The selection of indicators supported by sustainable observation data is the key to establishing a sustainable indicator system. Compared with developed countries, China accumulation of traditional statistical data is obviously insufficient. In particular, the construction of livable cities proposed by China is relatively short. The data base is relatively weak. Therefore, how to select indicators and establish an effective and feasible index system is particularly important. This paper mainly uses AHP and frequency analysis to achieve the establishment of general system indicators. The analytic hierarchy process mainly analyzes and synthesizes the connotation and indicators of livable cities, and selects targeted indicators. The frequency analysis method mainly selects the current research reports and papers on the evaluation of livable cities, and selects the frequency statistics. Use more frequent indicators. After establishing general sys-

tem indicators, indicators need to be screened to determine specific indicators. The evaluation indicators selected in this paper mainly include: economic development degree, social harmony degree, cultural richness, living comfort, and urban environmental status.

After selecting the indicators, the analytic hierarchy process is to decompose the decision problems into different hierarchies according to the general goal, the sub-goals, the evaluation criteria, and the specific preparation plan. Then, the eigenvectors of the judgment matrix are used. The method is to obtain the priority of each element of each level to the element of the previous level. Finally, the method of weighting the sum is used to merge the final weight of each alternative plan to the total target. The final weight is the best. Program. The so-called

"priority of priority" is a relative measure, which indicates the evaluation criteria or sub-goals of each alternative in a certain characteristic, the relative measure of superiority, and the importance of each sub-goal to the upper-level target. A relative measure of the degree. The analytic hierarchy process is more suitable for the target system with hierarchical and interlaced evaluation indicators, and the target value is difficult to quantitatively describe the decision problem. Its usage is to construct a judgment matrix and find its maximum eigenvalue. And the corresponding feature vector W, after normalization, is the relative importance weight of a certain level index to a related index of the previous level. The main evaluation indicators are selected accordingly:

Table 1. Livable Urbanity Evaluation Criteria (Long-term Stable)

Primary Indicator	Secondary Indicators	Weight Coefficient	Total Weight
Economic Development	Regional GDP / 10,000 yuan	0.0724	0.2885
	Per capita GDP / yuan	0.2161	
Social Harmony	Population density / (person / square km)	0.1436	0.3944
	Town medical insurance participation number / person	0.2509	
Cultural Richness	Number of ordinary colleges/schools	0.0836	0.1672
	Public library has a book number / 10,000	0.0836	
Urban Environmental Conditions	Soot removal / ton	0.1073	0.1499
	Harmless treatment rate of domestic garbage /%	0.0426	

Economic development. Because the city is the organization, management and coordination center of the regional economy, it is a high-density gathering place of economic factors and a carrier for various non-agricultural activities. Only by having a strong economic base, advanced industrial structure and strong development potential can a city provide sufficient employment opportunities and high income for urban residents to provide guarantees for the construction of material facilities in livable cities.

Social harmony. Every livable city that has been praised and longed by the public must have its unique urban cultural characteristics and urban spirit that have gained citizen recognition. The common cultural and spiritual shaping of the city should be an important part of the construction of a livable city, and it is the main embodiment of the soul and characteristics of a city. A livable city must have its own culture and gain a sense of belonging to the citizens. There are many indicators that reflect the cultural richness of livable cities, such as the number of ordinary higher education institutions and the number of books in public libraries.

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tions of higher learning and the number of books in public libraries can reflect the cultural richness of livable cities.

Urban environmental conditions. To evaluate whether a city is livable, it should first be measured by its impact on the whole city. If you do not consider this factor, it will lead to the fragmentation of the urban macro environment, and the livability is passive water. The amount of soot removal and the harmless treatment rate of domestic garbage can reflect the environmental conditions of livable cities.

### 3. Impact of Changes in Evaluation Indicators on the Ranking of Livable Cities

#### 3.1. Evaluation system

Main indicators;

Economic: Per capita GDP and the proportion of the tertiary industry to the total population;

Society: Population density, number of people participating in urban medical insurance;

Culture: Public library has the number of books and the number of ordinary higher education institutions;

Surroundings: Industrial smoke removal amount, domestic garbage harmless treatment rate.

#### 3.2. Check if the data is suitable for factor analysis

The premise of using factor analysis is that there is a linear relationship between variables, so that the reduction of variables can be achieved and the purpose of analysis

is facilitated. According to the correlation matrix of the variables, the correlation coefficient of most variables is greater than 0.3, which has a strong correlation. At the

same time, KMO test and Bartlett sphericity test are performed on the above variables. See the table below:

Table 2. KMO And Bartlett Inspection

Sampling Enough Kaiser-Meyer-Olkin Measure	0.695
Bartlett Sphericity Test	277.025
Approximate Chi Square	Approximate chi square

The analysis shows that the Bartlett sphericity test statistic observation value is 277.025, and the corresponding probability P is close to 0. If the significance level is 0.05, since the probability P is less than the significance level of 0.05, the null hypothesis should be rejected, and the correlation matrix and the unit matrix are considered. The difference. At the same time, the KMO value is 0.695, which is better than the standard, and the factor analysis method can be applied.

3.3. Extraction factors and results analysis

According to the correlation coefficient matrix of the original variable, the principal component analysis method is used to extract the factor and select the eigenvalue greater than 1. It can be seen that most of the information of the variables can be analyzed by factors, and information loss is less. The overall effect of factor extraction is better. The total variance of the explanation is as follows:

Table 3. explains the total variance

Ingredient	Initial eigenvalue			Extract square sum loading		
	Total	Variance(%)	Accumulation(%)	Total	Variance(%)	Accumulation(%)
1	3.963	66.052	66.052	3.963	66.052	66.052
2	0.057	0.743	99.526			
3	1.771	29.518	95.570	1.771	29.518	95.570
4	2.453	44.378	89.345	2.453	44.378	89.345
5	0.095	1.589	99.287			
6	0.128	2.128	97.698			
7	0.026	0.433	99.720			
8	0.017	0.280	100.00			

Factor analysis shows that changes in per capita GDP, population density, and number of people participating in urban health insurance will have a significant impact on the ranking of livable cities.

4. Solving Multiple Nonlinear Equations between Uncertain Factors and Indicators

Multivariate nonlinear equations:

$$F(x)=0$$

In the above formula:  $F(x)=(f_1(x), f_2(x), \dots, f_n(x))^T \in R^n$ ,  $x \in R^n$ ,  $f_i: R^n \rightarrow R^1$ ,  $i=1,2,\dots,n$ , It is a second-order continuous differentiable function. We set all the real roots of the nonlinear equations to be included in the n-dimensional cube.

$\Omega_0 = \{x \in R^n | c < x < d, c = (c_1, c_2, \dots, c_n)^T \in R^n, b = (b_1, b_2, \dots, b_n)^T \in R^n\}$ .  $x^n$  is any fixed solid root of the equations. N-dimensional cube

$$\Omega = \{x \in R^n | a \leq x \leq b, a = (a_1, a_2, \dots, a_n)^T \in R^n, b = (b_1, b_2, \dots, b_n)^T \in R^n\}$$

It only contains the real root  $x^n$  of the equation group (1).  $a_i \cdot b_i \in (c_i, d_i), i=1,2,\dots,n$ , And on  $\Omega - \{x^n\}$ ,  $F(x)^T F(x) \neq 0$ . Get the relationship between uncertainties and indicators.

From this, we can get the ranking relationship of the eight major cities:

First: Lianyungang; Second: Suzhou; Third: Xuzhou; Fourth: Suqian; Fifth: Zaozhuang; Sixth: Shangqiu; Seventh: Jining; Eighth: Huaibei. Taking Xuzhou as an example, we further analyze the livable cities in Xuzhou based on the large amount of data collected, and then accurately analyze the livable construction in Xuzhou based on the standards of livable cities. The main evaluation indicators of Xuzhou are shown in Table 4.

5. Suggestions for Further Improving the Livability Level of Cities

First of all, how to improve the regional GDP and per capita GDP is the basis and premise of livable cities. Xuzhou should scientifically plan the scale and development intensity of urban construction according to the resource and environmental carrying capacity and economic and social development, and according to its own resources and A series of Encouraging Entrepreneurship Policies strive to increase regional GDP and increase employment and minimum wages by increasing positions, thereby increasing people's GDP.

Reasonably improve and improve the education system, invest in a higher level of teachers, and provide more favorable conditions for cultivating higher quality talents. Strengthening the construction of ecological civilization and forming a spatial pattern, industrial structure, devel-

opment mode and lifestyle that conserves resources and protects the environment can create a good production and living environment and make the city more livable.

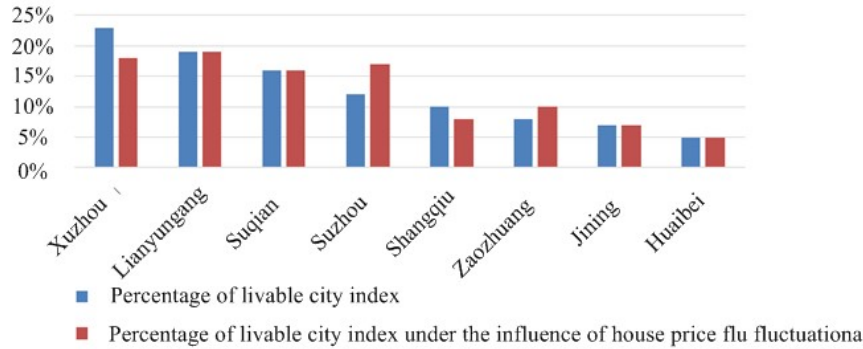


Figure 1. Relationship between uncertainties and indicators

Table 4. Main Evaluation Indicators of Xuzhou

Primary Indicator	Secondary Indicators	Standard Value	According
Economic Development	Per capita GDP/10,000 yuan	10	China's eco-city standards
	Employment of the tertiary industry as a percentage of the total number of people /%	45	The standard value of the Ingles index system Economic development
Cultural Richness	Public library has a book number/100,000 copies	30	"China National Education for All Report" 2010 target
	Number of schools in ordinary colleges and universities	10	Extrapolation of sample survey
Social Harmony	Population density / (person / square kilometer)	3500	China's eco-city standards
	Number of people participating in urban medical insurance / 10,000 people	819	China's eco-city standards
Urban Environmental Conditions	Industrial dust removal / tons	700	China's eco-city standards
	Harmless treatment rate of domestic garbage /%	95	China's eco-city standards

Improve the evaluation system of ecological civilization, and urge local governments to coordinate the relationship between economic and social development and ecological environmental protection. In the past, for a long period of time, the economic development indicators in the local government evaluation system accounted for a large weight, and the ecological environmental protection indicators accounted for a small weight. To speed up the management of "urban diseases" and improve the level of livableness in urban areas, we must establish and improve the ecological civilization evaluation system. It is necessary to correct the view of GDP in the supremacy of GDP, increase the weight of ecological civilization performance in the assessment, and urge local governments to coordinate the relationship between economic and social development and ecological environmental protection, and actively promote the new urbanization with

people as the core. Reasonably improve and improve the education system, invest in a higher level of teachers, and provide more favorable conditions for cultivating higher quality talents.

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