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Comprehensive Evaluation of Social Sustainable Development in Wumeng Mountain Area

Taking Liupanshui as an Example*

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***Abstract*—Liupanshui is an important member of the Wumeng Mountain contiguous destitute area, so studying its social sustainable development has very important practical significance. This paper firstly gives the comprehensive evaluation index system of social sustainable development of Liupanshui, and then empowers the evaluation indicators by means of improved entropy weight method. Finally, it uses TOPSIS to study the sustainable development of Liupanshui society. The results show that the social sustainable development of Liupanshui becomes better, but Liupanshui should increase the intensity of housing renovation work, further improve the social security system, continue to increase social security coverage and strengthen infrastructure construction.**

Keywords—Wumeng mountain area; TOPSIS method; social sustainable development; comprehensive evaluation

I. INTRODUCTION

Achieving sustainable social development is an urgent need of a city, especially some poverty-stricken areas. The excessive use of limited resources has created a number of problems. Liupanshui, a typical mining city, is an important member of the Wumen Mountain a, so achieving its social sustainable development is crucial. There are not many studies on sustainable social development. Most of the researches on urban sustainable development are comprehensive urban sustainable development researches, such as research on sustainable development of resources, environmental sustainable development, economic sustainable development research and social sustainable development research. Zhu Li (2006) established an environmental, economic and social urban sustainable development evaluation index system, and comprehensively evaluated and predicted the environmental, economic and social sustainable development of Guangzhou by using the entropy method [1]; Zhang Ping (2009) believed that the sustainable economic and social development of Qinghai Tibetan areas is of great practical significance for building a prosperous, civilized and new Qinghai, promoting national unity, safeguarding the harmonious reunification of the motherland, and building a well-off society in an all-round way [2]; Liu Yulin (2007) discussed the relationship between the sustainable development of Tibet's ecological economy and society and came to the conclusion that ecological sustainable development is the premise of sustainable development system, economic sustainable development is the core of sustainable development system, and social sustainable development is the goal of sustainable development. [3]; Lv Zhixian (2008) put forward the countermeasures and suggestions for the sustainable development of Yanling County from the perspective of society, environment and economy based on the social development of Yanling County and the views and opinions of other scholars, [4] Yu Mingjiang (2004) believes that the complete and accurate grasp of Marx's social sustainable development theory is conducive to the construction of China's social sustainable development theory. We should choose the values that meet the requirements of the times, actively expand high-tech, green technology and human resources, scientifically establish current and future industrial comparative advantage strategies, and explore a social sustainable development path that is suitable for China's national conditions and promotes the coordinate development of society, economy, population, environment and sustainable development. [5]; Lian Xi (2007) established the index system of sustainable development evaluation in Fuzhou from the three perspectives of resources and environment, economy and society on the basis of summarizing the development status of Fuzhou, combined the analytic hierarchy process and the analytic hierarchy process to calculate the interests of each index, and then the multi-objective linear weighting function method is used to calculate the resource and environmental

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sustainability index, economic sustainability index and social sustainability index from 1996 to 2005 [6]; Liu Xianqi and Wang Xiaohong (1996) held that the theory of social sustainable development is a new theory of social development under the historical conditions of deteriorating global problems caused by unsustainable production, consumption and the old international order. It advocates that we should realize the integrated and coordinated development of socio-economic and cultural values based on the maintenance of natural resources and environment [7]; Ma Wei, Liu Hua and Jin Xin et al. (2015), based on the energy footprint theory, made quantitative evaluation and analysis on the ecological economic system of Gansu Province by calculating the 2012 energy carrying capacity and energy footprint of Gansu Province [8]. The above research on social sustainable development is basically based on qualitative research, and less are quantitative researches. There is research on a certain region but no research is on the social sustainable development of Liupanshui, and there are some errors in the method of empowerment and unreasonable evaluation methods. This paper will improve the traditional entropy weight method, overcome its drawbacks, expand its scope of use, empower the indicators, and finally use the improved TOPSIS to comprehensively evaluate the social sustainable development of Liupanshui.

II. EVALUATION INDEX SYSTEM CONSTRUCTION

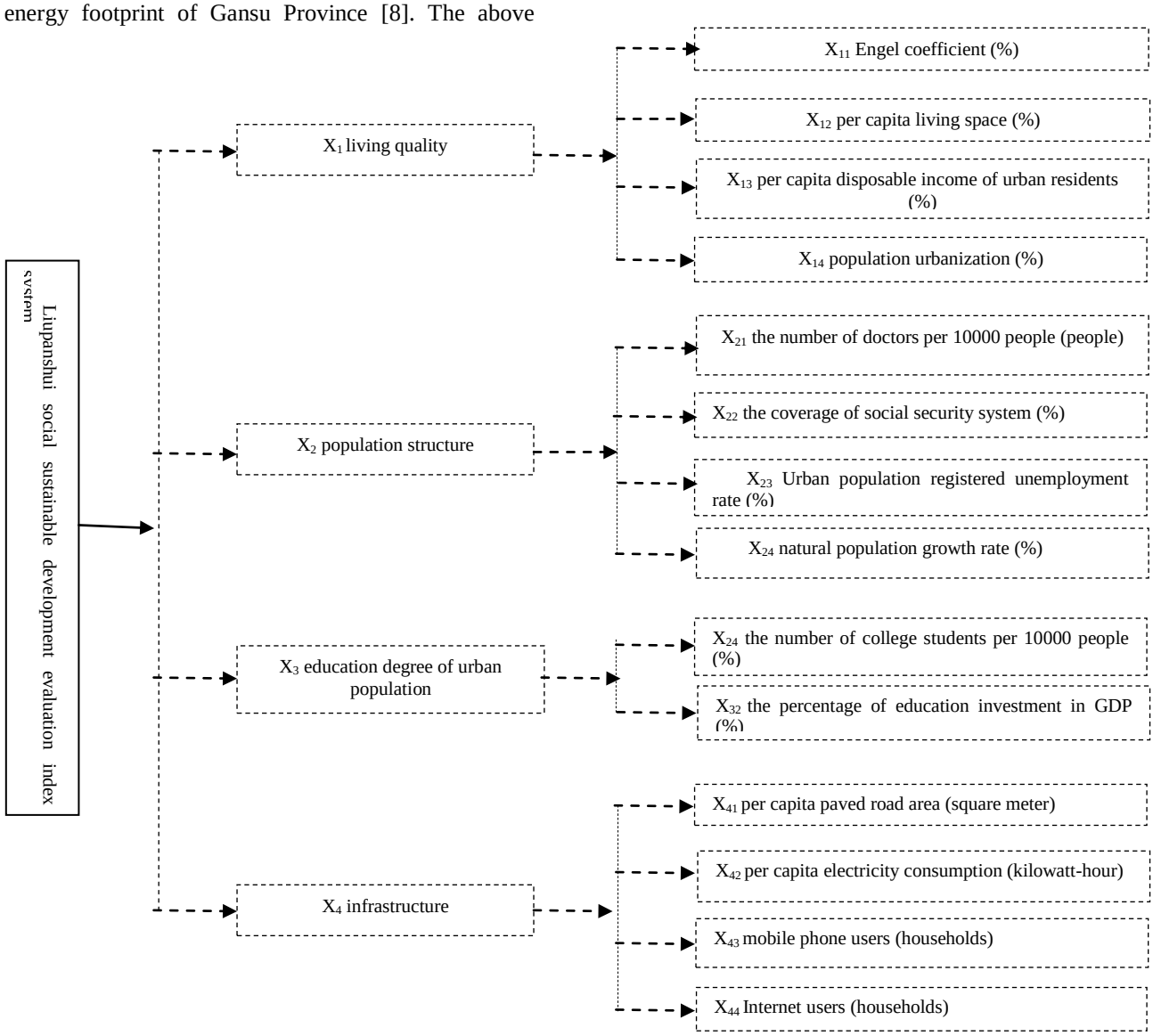

Fig. 1. Comprehensive evaluation indexes system of social sustainable development for Liupanshui.

Based on the sustainable development system of the United Nations Commission on Sustainable Development [9], the UK Sustainable Development Indicator System [10] and some of the domestically cited literature, this paper uses principal component analysis, step-by-step analysis, and grey correlation to screen indicators according to the

principles of systemicity, feasibility, comparability, integrity, scientificity, easy-to-select and representativeness and establish social sustainable development indicator system of Liupanshui with four dimensions including quality of life, population structure, urban population education, and infrastructure and a total of 14 indicators, as shown in "Fig. 1".

III. RESEARCH METHODS

A. Standardization of Indicators

i j $X_{ij}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$ m n $X_{m\times n}$ If the number N indicator value of the number N object to be evaluated is recorded, the original data forms a matrix of rows and columns. Considering that different indicators of the object to be evaluated often have different dimensions and dimension units, it is necessary to standardize the indicators.

1) Standardization of positive indicators: $X_{ij}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$ i j Y_{ij} Set the value of number N indicator of the number N object to be evaluated, and if it will be better when index is superior, it is standardized according to the following formula [11],

$$Y_{ij}=\frac{X_{ij}-\min\limits_{1\le i\le m}\left(X_{ij}\right)}{\max\limits_{1\le i\le m}\left(X_{ij}\right)-\min\limits_{1\le i\le m}\left(X_{ij}\right)}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$$

(1)

2) Standardization of negative indicators: $X_{ij}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$ i j Y_{ij} Set the value of number N indicator of the number N object to be evaluated, and if it will be better when index is worse, it is standardized according to the following formula [11],

$$Y_{ij}=\frac{\max\limits_{1\le i\le m}\left(X_{ij}\right)-X_{ij}}{\max\limits_{1\le i\le m}\left(X_{ij}\right)-\min\limits_{1\le i\le m}\left(X_{ij}\right)}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$$

(2)

3) Standardization of moderate indicators: $X_{ij}\left(i=1,2,\cdots,m;\ j=1,2,\cdots,n\right)$ i j Y_{ij} Set the value of number N indicator in the number N year, and the indicator is of moderate size, it is standardized according to the following formula [11],

$$Y_{ij}=\begin{cases}1-\dfrac{X_j-X_{ij}}{\max\left(X_j-\min\limits_{1\le i\le m}\left(X_{ij}\right),\max\limits_{1\le i\le m}\left(X_{ij}\right)-X_j\right)}, & \min\limits_{1\le i\le m}\left(X_{ij}\right)<X_{ij}<X_j\\ 1-\dfrac{X_{ij}-X_j}{\max\left(X_j-\min\limits_{1\le i\le m}\left(X_{ij}\right),\max\limits_{1\le i\le m}\left(X_{ij}\right)-X_j\right)}, & X_j<X_{ij}<\max\limits_{1\le i\le m}\left(X_{ij}\right)\\ 1, & X_{ij}=X_j\end{cases}$$

(3)

B. Improved Entropy Weight Method Determines Weight

$r_{ij}=0$ $r_{ij}ln\left(r_{ij}\right)=0$ The entropy weight method [12] is widely used in the index weighting, and the entropy can be used to calculate the weight of the index. In order to overcome the limitations of the special agreement of the entropy weight method, this paper improves it. It does not need to assume the special agreement and scope of application is expanded, making it more convenient to use. The specific calculation steps for determining the weight using this method are as follows:

- Method for determining the entropy value of each index

$$P_j=-K\sum_{i=1}^{m}r_{ij}ln\left(r_{ij}\right)$$

(4)

$$r_{ij}=\frac{Y_{ij}+1}{\sum\limits_{i=1}^{m}\left(Y_{ij}+1\right)}\left(K=\frac{1}{ln\left(m\right)};\ j=1,2,\cdots,n\right)$$ in the formula

- Method for determining the diversity factor of each indicator

$$H_j=1-P_j$$

(5)

- determination method of Weight

The standardization of the index diversity factor can be used to obtain the weight. The calculation formula is:

$$\omega_j=\frac{H_j}{\sum\limits_{j=1}^{n}H_j}$$

(6)

C. Improving the TOPSIS Method

The TOPSIS method [13], also known as Technique for Order Preference by Similarity to Ideal Solution, is a commonly used method for multi-objective decision making. The specific steps are as follows:

- Standardized processing of data, using standardized data to establish a standardized matrix

Y The data is standardized processed by using equations (1), (2), and (3), and a standardized data matrix is established.

- selection of good and bad solution

The best and worst solutions in the normalized data are selected.

$$Y^+=\left(y_1^+,y_2^+,\cdots,y_n^+\right)\qquad Y^-=\left(y_1^-,y_2^-,\cdots,y_n^-\right)$$

$y_1^+=\max\left(Y_{1j},Y_{2j},\cdots,Y_{mj}\right),\ j=1,2,\cdots,n$

$y_1^-=\min\left(Y_{1j},Y_{2j},\cdots,Y_{mj}\right),\ j=1,2,\cdots,n$ Optimal solution; the worst solution, where;

- According to the Mahalanobis distance, the distance between the optimal value and the worst value of the evaluation index is determined. This method has less calculation step of distance than the original TOPSIS method, which is simpler and worthy of promotion.

$$D_i^+ = \sum_{j=1}^{n} W_j^* \left| Y_{ij} - Y_j^+ \right|, i = 1, 2, \cdots, m. \quad (7)$$

$$D_i^+ = \sum_{j=1}^{n} W_j^* \left| Y_{ij} - Y_j^- \right|, i = 1, 2, \cdots, m. \quad (8)$$

$D^+ = \left(D_1^+, D_2^+, \cdots, D_m^+ \right)$ $D^- = \left(D_1^-, D_2^-, \cdots, D_m^- \right)$ Distance vector of optimal value; distance vector of worst value

- Calculating the relative closeness of each target:

$$C_i = D_i^- / (D_i^- + D_i^+), i = 1, 2, ..., m. \quad (9)$$

C_i The larger value indicates the object being evaluated is closer to the optimal level, and the object is better; otherwise, it will be worse. The objects are sorted according to the relative closeness to form a decision basis.

IV. Comprehensive Evaluation of Social Sustainable Development of Liupanshui

A. Raw Data

According to the 2002-2011 Guizhou Statistical Yearbook and the China Urban Statistical Yearbook, the index data in the evaluation index system are sorted out. The raw data of the indicators are shown in "Table I".

B. Indicator Standardization and Weight

Combining with the indicator types and raw data in "Table I", the standardized data of the forward index is calculated by using the formula (1) in the text, and the normalized data of the negative index is calculated by the formula (2), and the standardized data "Table II" of the evaluation index is calculated.

TABLE I. The Original Datas of Evaluation Indexes

No	criterion layer	index level	pointer type	2001(5)	2002(6)	...	2009(13)	2010(14)
1	X_1	X_{11}	moderate indicators	39	33.7	...	41.5	39.9
2		X_{12}	positive indexes	12.2	19.63	...	26.7	28.6
3		X_{13}	positive indexes	5146	5533.5	...	13116	13919
4		X_{14}	positive indexes	49.65	49.54	...	57.5	58.3
5	X_2	X_{21}	positive indexes	16	16	...	17	24
6		X_{22}	positive indexes	2.09	5.66	...	10.65	16.93
7		X_{23}	Negative indicators	3.4	4.1	...	3.63	3.77
8		X_{24}	moderate indicators	10.17	13	...	6.72	6.84
9	X_3	X_{31}	positive indexes	9	13	...	22.8.	139.15
10		X_{32}	positive indexes	1.7	1.6	...	1.8	1.9
11	X_4	X_{41}	positive indexes	6.21	7.25	...	8.09	10.15
12		X_{42}	positive indexes	275.2	364.01	...	487.5	536.8
13		X_{43}	positive indexes	6.8	8.96	...	75.3	83.6
14		X_{44}	positive indexes	0.16	0.19	...	7.87	9.46

[a.] Remarks: (1), ... (14) in the first row of "Table I", representing 1-14 columns.

1) Standardization of indicators

a) Standardization of positive indicators: Taking the data standardization of the "urbanization level" indicator in 2001 as an example, the rest of the standardized data is deduced by analogy. The standardized data of the indicators are shown in the fourth line of "Table II".

Bring the "urbanization level" data 49.65 in the fourth row and the fifth column of "Table 1" into the formula (1), and the standardized data of "urbanization level" 0.0126 can be obtained, and it is listed in the fourth row and the fifth column in "Table II".

b) Standardization of negative indicators: Taking the data standardization of the "Urban Population Registered Unemployment Rate" as an example in 2001, the rest of the standardized data is similar, and the standardized data of the indicators are shown in the 7th line of "Table II".

Bringing the "urbanization level" data 3.4 of the 7th row and the 5th column in "Table I" into the formula (2), and the standardized data of "urbanization level" 0.1538 is obtained, and it is listed in the 7th row and the 5th column in "Table II".

c) Standardization of moderate indicators: Taking the data standardization of the indicator "Engel coefficient" of the moderate indicator in 2001 as an example, the rest of the standardized data is similar, and the standardized data of the indicator is shown in the first line of "Table II".

According to the actual situation in China, most scholars believe that the "Engel coefficient" of Chinese cities and towns is 37.9%, which is a level of wealth. Taking the "Engel coefficient" in 2001 as an example, the data in the first row and the fifth column of "Table I" 39 is brought into the formula (3), the standardized data of the "Engel

coefficient" 0.1410 can be obtained, and is listed in the first row and the fifth column in "Table II".

TABLE II. THE STANDARDIZED DATAS OF EVALUATION INDEXES

No	criterion layer	index level	pointer type	2001(5)	2002(6)	...	2009(13)	2010(14)
1	X_1	X_{11}	moderate indicators	0.1410	0.5385	...	0.4615	0.2564
2		X_{12}	positive indexes	0.0000	0.4246	...	0.8286	0.9371
3		X_{13}	positive indexes	0.0000	0.0442	...	0.9085	1.0000
4		X_{14}	positive indexes	0.0126	0.0000	...	0.9087	1.0000
5	X_2	X_{21}	positive indexes	0.2727	0.2727	...	0.3636	1.0000
6		X_{22}	positive indexes	0.0000	0.2406	...	0.5768	1.0000
7		X_{23}	Negative indicators	0.1538	0.6923	...	0.3308	0.4385
8		X_{24}	moderate indicators	0.7111	1.1004	...	0.2366	0.2531
9	X_3	X_{31}	positive indexes	0.0000	0.0307	...	0.1060	1.0000
10		X_{32}	positive indexes	0.6000	0.4000	...	0.8000	1.0000
11	X_4	X_{41}	positive indexes	0.0000	0.2640	...	0.4772	1.0000
12		X_{42}	positive indexes	0.3384	0.5630	...	0.8753	1.0000
13		X_{43}	positive indexes	0.0000	0.0281	...	0.8919	1.0000
14		X_{44}	positive indexes	0.0000	0.0032	...	0.8290	1.0000

a. Remarks: it indicates the rounding off in the standardization process of indicators.

2) Weight calculation of indicators: According to the step of calculating the index weight by the entropy weight method, the normalized data in "Table II" is brought into the formulas (4)-(6), and the weight of each index is calculated, as shown in "Table III".

TABLE III. THE WEIGHTS OF EVALUATION INDEXES

indicator	X_{11}	X_{12}	X_{13}	X_{14}	X_{21}	X_{22}	X_{23}
entropy weight	0.0264	0.0534	0.0960	0.0797	0.0669	0.0562	0.0672
indicator	X_{24}	X_{31}	X_{32}	X_{41}	X_{42}	X_{43}	X_{44}
entropy weight	0.0782	0.0823	0.0677	0.0521	0.0890	0.0964	0.0885

C. Calculating the Relative Nearness Degree

According to the formula (7)-(9) for calculating the relative nearness degree, the relative nearness degree of each evaluated object can be calculated, and according to the size of the relative nearness degree, the social sustainable development status of each year is sorted as shown in "Table IV"

TABLE IV. THE RELATIVE NEARNESS DEGREES AND RANKING FOR EVERY YEAR

Year	**2001**	**2002**	**2003**	**2004**	**2005**
relative close degree	0.1515	0.2937	0.2797	0.3132	0.2834
sort	10	8	9	6	7
year	2006	2007	2008	2009	2010
relative close degree	0.3440	0.4494	0.4930	0.6304	0.8727
sort	5	4	3	2	1

D. According to the Changes in the Relative Close Degree for Each Year

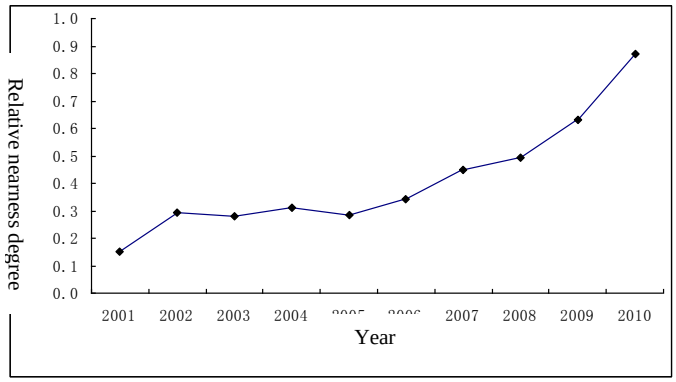

Fig. 2. The changing figure of relative nearness degrees for every year.

E. Results Analysis and Recommendations

According to the relative close degree sort and change chart of each year, it can be seen that the social sustainability of Liupanshui: relatively stable from 2001 to 2005, and the sustainability index is small; the sustainability index has increased year by year from 2006 to 2010 and has shown a trend of rapid growth, which is inseparable from Liupanshui's building of national health cities, civilized cities, livable cities, eco-civilized cities, Liupanshui's efforts to gradually increase waste, the introduction of implementation method of waste management in Liupanshui City Center Planning Area, the construction of the Liupanshui urban sewage waste treatment project and the greening construction on both sides of the urban road.

While the social sustainability of Liupanshui is getting better and better, we have also found some problems. In order to make the social sustainability of Liupanshui better, we should do some work in the following aspects:

Liupanshui should increase the efforts of housing renovation and construction, so that more people can enjoy the housing benefits brought by the government; further improve the social security system, increase the coverage of social security, and enable more people's welfare to benefit the people; continue to enhance infrastructure construction, especially road repair, pavement and basic housing renovation projects.

V. CONCLUSION

This paper discusses the method of index weighting and evaluation methods, makes improvements to it and applies it to the comprehensive evaluation of sustainable development of Liupanshui society. Features and innovations are mainly reflected in the following aspects:

- In view of the drawbacks of the original entropy weight method, it has been improved to make it more applicable, providing a new method of index weighting;
- The improvement is made to the traditional TOPSIS method, and the changing situation of social sustainable development of Liupanshui is given by this method. This method can be applied not only to the comprehensive evaluation of social sustainable development, but also to similar comprehensive evaluation. It is worth learning and promotion.

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