Research on Evaluation of Circular Economy Development

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Abstract: For the current evaluation methods are imperfect in circular economy development level, this paper puts forward the evaluation index system of circular economy developing level constituted by 4 categories containing resources consumption, environmental disturbance, recycling and social development and 16 indicators, they can reflect the characteristic of resources recycling specially, and AHP is used for ranking the index, and fuzzy comprehensive evaluation method is adopted for evaluating regional circular economy developing level.
Keywords: Region; Circular economy; Development level; Evaluation

1 Introduction

Evaluation of circular economy developing level is assessment circular economy developing level in a certain region, though weights determined and comprehensive analysis, judge the regional development level of circular economy. Foreign country emphasized on practical development of circular economy because of relatively advanced level of development, so they do little research on this content. As the relatively backward domestic development level, we need to conduct quantitative research on this issue. The current circular economy development level evaluation index has been in research in China, but on analysis of existing studies, most of evaluation index system is remain in the constructing phase, and mainly exit the following three deficiencies: First, the current index system mostly is for eco-industrial or agricultural development of circular economy, suitable for different regions and could be widespread application's index system of circular economy development level is still rare; Second, some indicators did not set a specific value, and poor to be application in practice; Third, the index system has not proposed specific evaluation methods, the operability to measure regional circular economy development is not strong.

It could be evaluated by several methods in circular economy development level, but none of them could be generally recognized[1]. This paper argues that circular economy development level has a certain degree of ambiguity, for example in performance level classification and impact indicators, so this paper put forward to evaluate circular economy development level by fuzzy comprehensive method.

2 Evaluation Index System Construction

Comprehensive analysis of other relevant research[2-5], this article put forward the evaluation index system of circular economy development level constituted by 4 categories contains resources consumption, environmental disturbance, recycling and social development and 16 indicators(see figure 1), so that can measure circular economy development from the quantitative point of view.

Among the indexes, the C3 elasticity in water use means water using rate and the ratio of GDP growth, used to reflect the flexibility of water using impact on economy growth, is the index to determine the water saving and reusing level internal economy activity, which means the evaluation index system attention to water resources recycling and conservation. The value of other specific targets and calculation can be calculated by the Statistical Yearbook.

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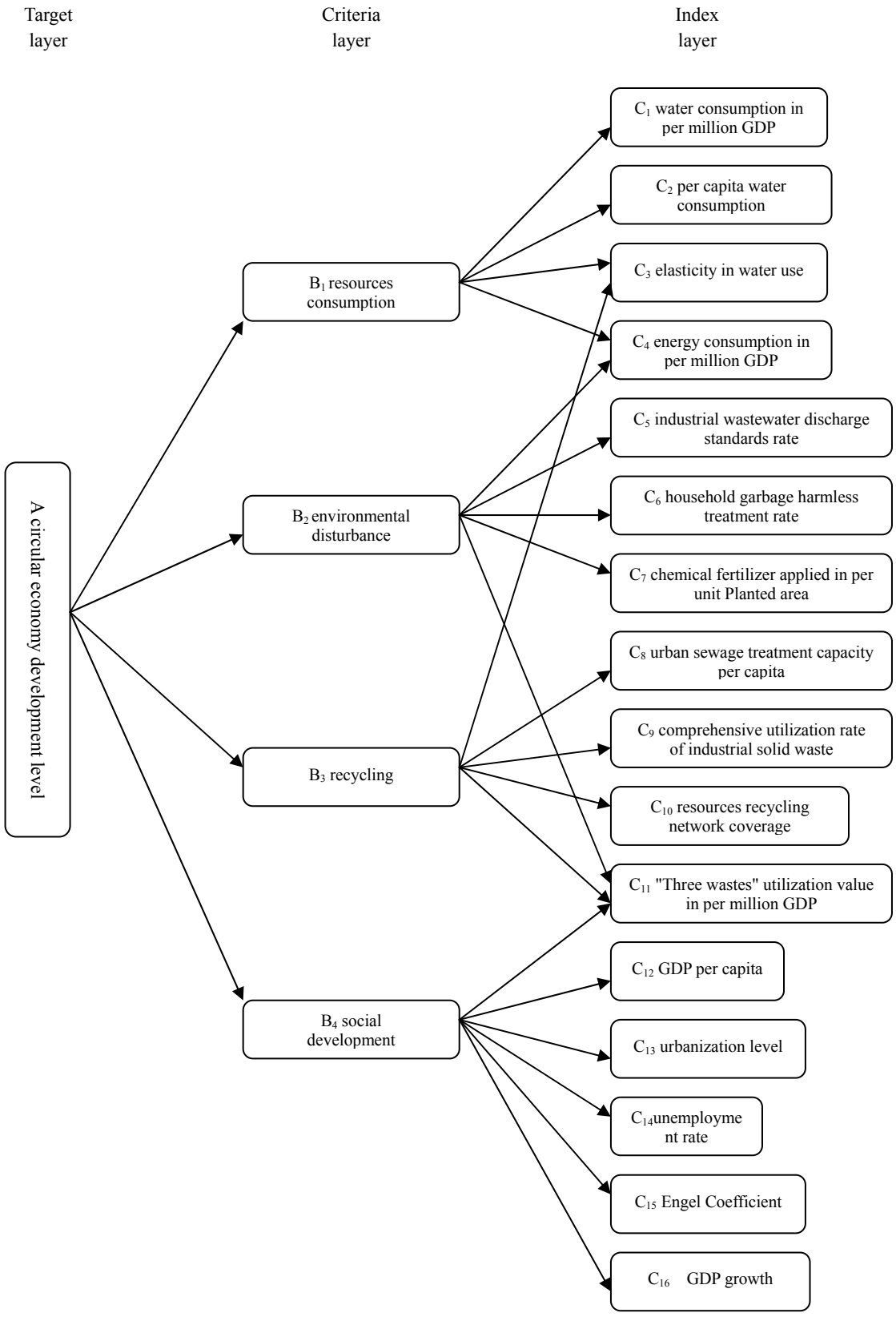

Figure 1 The Structure Model of Evaluation Index System of Circular Economy Developing Level

3 Level Sort of Evaluation Index System

This paper mainly applies of AHP in stage of constructing the evaluation index system[6]. Advisory group composed twelve experts include the field of circular economy, agricultural economy, environmental engineering business management. After repeated consultation and induction, opinion tends to unity (Process is omitted).

3.1 Index single-level sorting

Using the geometric mean to calculate the relative importance coefficient W_{Bi} of matrix B_i (i=1,2,3,4) to A, and the process shown as Table 1.

Table 1 Detail Calculating Table of W_{Bi}

A	B_1	B_2	B_3	B_4	M_{Bi}	$\overline{W_{Bi}}$	W_{Bi}
B_1	1	1	1/3	1	1/3	0.7598	0.1787
B_2	1	1	1/3	1	1/3	0.7598	0.1787
B_3	3	3	1	1	9	1.7320	0.4074
B_4	1	1	1	1	1	1.0000	0.2352
∑	—	—	—	—	—	4.2516	1.0000

Now we Use the same method to calculate the matrix B-C_i, and the result shown as Table 2-5.

Table 2 Detail Calculating Table of W^1_{Ci}

B_1	C_1	C_2	C_3	C_4	M_{Ci}	$\overline{W_{Ci}}$	W_{Ci}
C_1	1	1	1	1/3	1/3	0.7598	0.1667
C_2	1	1	1	1/3	1/3	0.7598	0.1667
C_3	1	1	1	1/3	1/3	0.7598	0.1667
C_4	3	3	3	1	27	2.2795	0.4999
∑	—	—	—	—	—	4.5589	1.0000

Table 3 Detail Calculating Table of W^2_{Ci}

B_2	C_4	C_5	C_6	C_7	C_{11}	M_{Ci}	$\overline{W_{Ci}}$	W_{Ci}
C_4	1	1/3	1/3	1/3	1	1/27	0.5173	0.0887
C_5	3	1	1	3	3	27	1.9332	0.3316
C_6	3	1	1	3	3	27	1.9332	0.3316
C_7	3	1/3	1/3	1	1	1/3	0.8027	0.1376
C_{11}	1	1/3	1/3	1	1	1/9	0.6444	0.1105
∑	—	—	—	—	—	—	5.8308	1.0000

Table 4 Detail Calculating Table of W^3_{Ci}

B_3	C_3	C_8	C_9	C_{10}	C_{11}	M_{Ci}	$\overline{W_{Ci}}$	W_{Ci}
C_3	1	3	1	1/3	1/3	1/3	0.8027	0.1496
C_8	1/3	1	1/3	1/3	1	1/27	0.5173	0.0965
C_9	1	3	1	1	1	3	1.2457	0.2323
C_{10}	3	3	1	1	1/3	3	1.2457	0.2323
C_{11}	3	1	1	3	1	9	1.5519	0.2893
∑	—	—	—	—	—	—	5.3633	1.0000

Table 5 Detail Calculating Table of W^4_{Ci}

B_4	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	M_{Ci}	$\overline{W_{Ci}}$	W_{Ci}
C_{11}	1	1	3	3	1	1	9	1.4423	0.2243
C_{12}	1	1	3	3	1	1	9	1.4423	0.2243
C_{13}	1/3	1/3	1	1	3	1/3	1/9	0.6934	0.1078
C_{14}	1/3	1/3	1	1	1/3	1	1/27	0.5774	0.0898
C_{15}	1	1	1/3	3	1	1/3	1/3	0.8327	0.1295
C_{16}	1	1	3	1	3	1	9	1.4423	0.2243
∑	—	—	—	—	—	—	—	6.4305	1.0000

3.2 Index overall-level sorting

Overall sorting shown as Table 6.

Table 6 Detail Calculating Table of Hierarchical Total Sequencing

	B_1	B_2	B_3	B_4	overall sorting
	W_{B1}=0.1787	W_{B2}=0.1787	W_{B3}=0.4074	W_{B4}=0.2352	
C_1	W^1_{C1}=0.1667	0	0	0	0.02979
C_2	W^1_{C2}=0.1667	0	0	0	0.02979
C_3	W^1_{C3}=0.1667	0	W^3_{C3}=0.1496	0	0.09074
C_4	W^1_{C4}=0.4999	W^2_{C4}=0.0887	0	0	0.10518
C_5	0	W^2_{C5}=0.3316	0	0	0.05926
C_6	0	W^2_{C6}=0.3316	0	0	0.05926
C_7	0	W^2_{C7}=0.1376	0	0	0.02459
C_8	0	0	W^3_{C8}=0.0965	0	0.03931
C_9	0	0	W^3_{C9}=0.2323	0	0.09464
C_{10}	0	0	W^3_{C10}=0.2323	0	0.09464
C_{11}	0	W^2_{C11}=0.1105	W^3_{C11}=0.2893	W^4_{C11}=0.2243	0.19029
C_{12}	0	0	0	W^4_{C12}=0.2243	0.05278
C_{13}	0	0	0	W^4_{C13}=0.1078	0.02537
C_{14}	0	0	0	W^4_{C14}=0.0898	0.02112
C_{15}	0	0	0	W^4_{C15}=0.1295	0.03046
C_{16}	0	0	0	W^4_{C16}=0.2243	0.05278
∑	1.0000	1.0000	1.0000	1.0000	1.0000

The next step is consistency test. The weight is reasonable and effective because of C • R<0.1 so that meet the consistency test requirements and could be the evaluation criterion of circular economy development level.

4 Fuzzy Comprehensive Evaluation of Circular Economy Development Level

4.1 Defined evaluation set of circular economy development level

Circular economy development level should be divided into four stages from strong to weak: highly advanced stage, moderately advanced stage, initial development stage, not development stage. That is:

Evaluation set V =(V_1, V_2, V_3, V_4)=(highly advanced stage, moderately advanced stage, initial development stage, not development stage)

$$V_1 \in [0.75,1],\quad V_2 \in [0.5,0.75),\quad V_3 \in [0.25,0.5),\quad V_4 \in [0,0.25)$$

4.2 Determine membership

This paper adopts lower semi-trapezoidal membership function and rising semi-trapezoidal membership function. Cost-based indicators adopt lower semi-trapezoidal membership function, and the index concludes C_1, C_2, C_3, C_4, C_7, C_{14}, C_{15}, membership function is:

$$\mu_{ij}(x_i)=\begin{cases}1 & x_i \le \min a_i \\ \dfrac{\max a_i - x_i}{\max a_i - \min a_i} & \min a_i < x_i \le \max a_i \quad i=1,2,\mathrm{L},n \\ 0 & \max a_i < x_i\end{cases}$$

Benefit-based indicators adopts rising semi-trapezoidal membership function, and the index conclude C_5,C_6,C_8,C_9,C_{10},C_{11},C_{12},C_{13},C_{16}, membership function is:

$$\mu_{ij}(x_i)=\begin{cases}0 & x_i \le \min a_i \\ \dfrac{x_i - \min a_i}{\max a_i - \min a_i} & \min a_i < x_i \le \max a_i \quad i=1,2,\cdots,n \\ 1 & \max a_i < x_i\end{cases}$$

In the function formula, x_i indicate the status of i-values, and max a and min a are upper and lower limits of I, and they should be given in advance based on refer to the developed country and backward areas. Individual qualitative indicators could value by expertise assessment

4.3 First-class comprehensive evaluation of fuzzy evaluation matrix

First-class comprehensive evaluation of fuzzy evaluation matrix is

$$S_i = W_i \circ R_i,$$

$$R = \{S_1, S_2, \ldots S_n\}^T$$

4.4 Second-class comprehensive evaluation of fuzzy evaluation matrix

$$S = W \circ R$$

We has known specific weight W, based on earlier results, we can get:

$$S = W \circ R = (W_1, W_2, W_3, W_4) \circ \begin{Bmatrix} R_{11} & R_{12} & R_{13} & R_{14} \\ R_{21} & R_{22} & R_{23} & R_{24} \\ R_{31} & R_{32} & R_{33} & R_{34} \\ R_{41} & R_{42} & R_{43} & R_{44} \end{Bmatrix} = (S_A, S_B, S_C, S_D)$$

After the results (S_A, S_B, S_C, S_D) normalized, we can get

$$S = (S_a, S_b, S_c, S_d)$$

Corresponding (S_a, S_b, S_c, S_d) with reviews rating (V_1, V_2, V_3, V_4), we can evaluate the circular economy development level in certain region, judging the level of circular economy development.

5 Conclusion

For the status quo of evaluation methods imperfect in circular economy development level, this article put forward the evaluation index system of circular economy developing level constituted by 4 categories contains resources consumption, environmental disturbance, recycling and social development and 16 indicators, reflected the characteristic of resources recycling specially, and to evaluate regional circular economy developing level by the fuzzy comprehensive evaluation method, so that enhance the evaluate ability in evaluation model and evaluation method of circular economy development level.

References

[1] Xiao Huamao. Research on Regional Circular Economy Development Mode and Evaluate System Summary[J]. Ecological Economy, 2007(4):52-55 (In Chinese)

[2] Jiang Hailong, Wang Jifu. The New Problems and Countermeasures in the Process of Revitalizing the old Northeast Industrial Base[J]. Economic Aspect, 2006(9):21-24 (In Chinese)

[3] A. Bruggink. A Fine Chemical Industry for Life Science Products: Green Solutions to Chemical Challenges[J]. Chemical Sciences, 2003,7:69-113

[4] Ayres Robert U. Metals Recycling: Economic and Environmental Implications[J]. Resources, Conservation and Recycling, 1997,11(21):45-173

[5] Xiang Laisheng. Analysis of Circular Economy Evaluation Index System[J]. China's Population. Resources and Environment, 2007(2):76-78 (In Chinese)

[6] Tian Jinfang, Su Mimi. Design and Evaluation Method Circular Economy Evaluation Index System [J]. Statistics and Decision, 2007(8):35-36 (In Chinese)