Urban Sustainable Development Capacity Evaluation Model Research and Application Based on entropy and distance functions

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Abstract

Sustainable development is an important issue in the world care, research and exploration on various aspects of sustainable development has also been concerned about the community, the issue of sustainable urban development is one of them. This will combine the connotation of sustainable urban development, to model for urban sustainable development capacity assessment model by studying entropy and distance function two mathematical theory, and to index data for the experimental area Shaoxing application examples, combined with the establishment of the evaluation model to evaluate their capacity for sustainable development, science and government departments to help understand the local level of sustainable urban development, provide the basis for scientific decision-making for sustainable urban development.

Keywords:Sustainable Urban Development; Entropy; Distance Function; Assessment Model

1 Introduction

Sustainable urban development is a social, ecological (environment), the economy maintained a high degree of harmony in the process. In order to fully reflect the status of this complex system, comprehensive evaluation of sustainable development need to adopt multi-index comprehensive evaluation method, that is more than describe the area being evaluated social, ecological (environment) and economic dimension different set of statistical indicators, transforming become dimensionless relative evaluation values, and the combination of these evaluation values to arrive at an assessment of the region on an overall assessment of sustainable development, the core of the problem is the evaluation methods[1]. In this paper, by studying entropy and two mathematical theory to model the distance function model for urban sustainable development capacity assessment model, and to index data for the experimental area Shaoxing application examples, combined with the establishment of its

evaluation model for sustainable develop the ability to evaluate the capacity of sustainable development for the city's comprehensive evaluation and analysis to provide a strong scientific basis.

2 Research Methods

2.1 Entropy

(1)Comprehensive evaluation of information entropy and weighting function

Suppose you need to evaluate the development of Shaoxing m years, the evaluation index system includes n indicators. This is a sample composed by m by n indices do comprehensive evaluation of the problem, this mathematical model is as follows:

On the field is:

$U = \{u_1, u_2, \ldots u_i \ldots u_m\}$ (i=1,2,⋯,m)

Each sample (evaluated) $u_i$with n indexes the data Characterization:

$u_i = \{X_{i1}, X_{i2}, \ldots X_{ij} \ldots X_{in}\}$ (j=1,2,... n)

Obtain initial data matrix evaluation system :$X = \{x_{ij}\}_{m\times n}$

The matrix is normalized initial matrix: $Y = \{y_{ij}\}_{m\times n}$

Entropy item j index values are: $e_j = -k\sum_{i=1}^{m} y_{ij} \ln y_{ij}$

M the number of samples where the constant k related to the system:$k = \frac{1}{\ln m}$

The difference between information and a utility value of an index depends on the index of information entropy $e_j$and 1:$d_j = 1 - e_j$

Estimates using entropy weight of each index, its essence is to use the index information to calculate the value of the coefficient, the value of the coefficient, the greater the importance of the evaluation, and finally get the item j index weights as follows: $w_j = \frac{d_j}{\sum_{j=1}^{n} d_j}$

(2)Evaluation of multi-evaluation system

For evaluation system multi-layer structure, according to the entropy can be additive, you can use the utility value of the underlying index information structure, determined by the ratio of the upper structure corresponding to the weight$w_j$value. Indicators for each type of utility value of the underlying structure of the summation, get all kinds of indicators of utility value and, denoted $D_k(k = 1,2, \ldots k)$, and then get the sum of all indicators utility value $D = \sum_{k=1}^{2} D_k$

The corresponding right weight class: $W_k = \frac{D_k}{D}$

2.2 Distance Function

Distance function model is a method of comprehensive evaluation model, the basic idea is: conducting a comparative evaluation of multi-subject similarity between indicators, the evaluation of the original data set mapping coordinates of points on the current situation in n-dimensional space, and target indicator, or the area of the ideal value of the optimal target value corresponds to the coordinates

of the point in space, the core is a comprehensive evaluation model calculate the distance value Status indicators and a target point, according to the size and distance of the comprehensive judgment evaluation of the relative levels of each object differences.

For the i-th index, the actual data set its target for $X_i(x_{i1}, x_{i2}, \dots x_{ij}), i = 1,2,3, \dots m,$ where m is the total number of index system indicators, j represent individual indicators included the number of data.

Set $(x_{i1}, x_{i2}, \dots x_{ij})$ corresponds to the status quo point coordinates j-dimensional space for $x_i(x_{i1}, x_{i2}, \dots x_{ij})$, namely the status quo coordinate space, and set the corresponding experimental zone Shaoxing urban sustainable development capacity in space target point coordinates$y_i(y_{i1}, y_{i2}, \dots y_{ij})$.

Calculate the distance value, that is seeking the status quo point in multidimensional space $x_i(x_{i1}, x_{i2}, \dots x_{ij})$ and the target point $y_i(y_{i1}, y_{i2}, \dots y_{ij})$ of$d_i(x_i, y_i)$ distance between two coordinate points (x_i, y_i).

Euclidean distance formula ：

$$d_i(x_i, y_i) = \sqrt[2]{\sum_{i=1}^{n} (\omega_i E_i - \omega_i)^2}$$

Among them, ω_i as an indicator x_i weights and $\sum_{i=1}^{n} \omega_i = 1$, E_i index normalized data, when $x_{ij}$to play role in promoting sustainable development, that is a positive indicator，$E_i = x_{ij}/y_{ij}$, contrary to reverse indicator,$E_i = y_{ij}/x_{ij}$.

3 Application Examples

3.1 Raw data: Shaoxing indicators and data

In this paper, Shaoxing City, Zhejiang Provience actual indicators and data, in accordance with the principles of data validity and integrity, from Shaoxing City, eco-development, social development perspectives focus on selected index system of sustainable development on two levels, including two-level indicators, thirteen two indexes. Shaoxing covers both social and ecological, indicators and data table below for Shaoxing experimental area.An index system diagram Shaoxing.

According to data provided by Shaoxing City (see Table 1), using the method of calculating the entropy of each index weights.

Table 1 Indicators data Shaoxing 2007--2012

	Index name and unit	2007	2008	2009	2010	2011	2012
Ecology	Per capita parkland area (square meters)	8.89	9.07	12.15	12.26	12.6	12.54

	Forest coverage rate (%)	51.8	51.8	54.03	54.03	54.03	54.03
	Total Energy (tce) per million GDP consumption	0.96	0.9	0.86	0.83	0.7058	0.66
	Every ten thousand yuan GDP water consumption (t)	106.24	96	93.54	80.78	57.94	59.56
	Sewage treatment rate (%)	78.14	76.51	75.93	79.9	81.94	84.82
	Ambient air quality standards (days) days	318	314	311	333	332	337
	Industrial solid waste comprehensive utilization (%)	80.84	80.43	80.88	93.15	91.09	92
	Garbage disposal rate (%)	100	100	100	100	100	100
	Per capita GDP (million)	45397	51075	54316	63770	75820	82966
	Tertiary industry to GDP (%)	34.8	36	37.5	38.6	39.8	41.2
Community	Urban residents per capita disposable income (RMB)	21971	24646	26874	30164	33273	36911
	Per capita net income of rural households (yuan)	9730	10950	12026	13651	15861	17706
	The registered	3.25	3.45	3.5	3.02	3.01	2.91

	urban unemployment rate (%)						

3.2 Calculation of weight right

According to 2007-2012 data Shaoxing indicators provided by entropy method to calculate the weight of each indicator.

The remaining index weights calculated by reference to the formula weight, and finally determine the weight of each index weight, the results see Table 2.

Table 2 weight values for each index

First index	Second index	Second index weight	First index weight value
Ecology	Eco-park per capita green area	0.0958	0.7772
	Forest coverage	0.1095	
	Total energy consumption per yuan GDP	0.0683	
	Every ten thousand yuan GDP water consumption	0.0819	
	Sewage treatment rate	0.0758	
	Ambient air quality standard number	0.0858	
	Industrial solid waste comprehensive utilization	0.1187	
	Garbage disposal rate	4.983 e^{-16}	
	Per capita GDP	0.0758	
	Tertiary industry GDP ratio	0.0658	
Community	Social urban residents per capita disposable income	0.0673	0.2228
	Per capita net income of rural households	0.0711	
	The registered urban unemployment rate	0.0844	

3.3 Comprehensive distance calculation

Application distance function method to establish sustainable urban development assessment model for calculating the weight of the right to primary and secondary indicators and standardizing the data, based on experimental zone of Shaoxing, City 2013 study of urban sustainable development capacity, establish experimental zone of Shaoxing City Sustainable Development Capacity index system, specifically see table 3.

Table 3 An index two indicators Unit 2013 reference standard and index weight basis

First Index	Second index	Unit	2013	reference standard and index	weight basis	Standardized data
Ecology	green area per capita ecological park	Square meter	12.62	>11 national standard	0.0958	1.1473
	forest coverage rate	%	54.03	>15 national standard	0.1095	3.6020
	total energy consumption per ten thousand yuanGDP	ton	0.63	<0.9 national standard	0.0683	1.4286
	water consumption Per ton ten thousand yuan GDP	ton	47.23	<150 national standard	0.0819	3.1759
	Sewage treatment rate	%	86.19	>85 national standard	0.0758	1.014
	Ambient air quality standard number of days	day	312	>280 national standard	0.0858	1.1143
	Industrial solid waste comprehensive utilization	%	92.69	>90 national standard	0.1187	1.0299
	Garbage disposal rate	%	100	>90 national standard	4.983 e^{-16}	1.1111
	GDP per capita in ten thousand	ten thousand	80212	>33000 national standar	0.0758	2.4307

	yuan			d		
	Tertiary industry accounted	%	42.1	>40 national standard	0.0658	1.0525
Community	Social urban residents per capita disposable income	yuan	40454	>24000 national standard	0.0673	1.6856
	The per capita net income of rural households	yuan	19618	>8000 national standard	0.0711	2.4523
	The registered urban unemployment rate	%	2.89	<1.2 national standard	0.0844	0.4152

Shaoxing City in 2013 for the evaluation of urban sustainable development capacity, with reference to Table 3, and then come to thirteen indicators Euclidean distance is calculated from the following equation integrated: $d=\sqrt[2]{\sum_{i=1}^{13} d_i}=0.3232$, and then come in Shaoxing City in 2013 sustainability assessment results.

4 Evaluation of results

For comparison, the evaluation on sustainable development in different regions, should be the appropriate level of pre-designed standard. Reference to the relevant research results at home and abroad, the design standard six levels to describe the extent of the sustainable development of the region[4], are shown in Table 4.

Table 4 Classification

Grade	comprehensive distance value d	basic features
1	d<0.15	High capacity for sustainable development
2	0.15<d<0.3	High capacity for sustainable development
3	0.3<d<0.45	Sustainable development in general
4	0.45<d<0.6	Poor capacity for sustainable development
5	0.6<d<0.75	Poor capacity for sustainable development

6	d>0.75	Worst capacity for sustainable development

Comprehensive distance value from the table 6 d = 0.3232, Shaoxing City in the table 6 indicate that the sustainable development capacity is general grade three in 2013.

Acknowledgement

In this paper, the research was sponsored by the National Technology R&D Program(2013BAJ04B04).

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