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Evaluation method for coalmining-based cities ecosystem based on attribute mathematical model with Huainan City as an example☆

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ABSTRACT

Attributive recognition model of coalmining-based cities ecosystem classification is developed in terms of attributive mathematical theory. Based on the analysis of main causes of coalmining-based cities ecosystem, the city vitality, city structure strength, city resilience ability, service functions and health status are chosen as the criterion indicators of coalmining-based cities ecosystem classification; the attributive measurement functions are constructed to compute the attributive measurement of single indicator and multi-indicator; and the synthetic attributive measurement is calculated by the AHP; the health classification of cities ecosystem are recognized by the confidence criterion. An empirical analysis is made by the proposed model and method, the synthetic evaluation results are better than fuzzy comprehensive evaluation method which validates the proposed model feasible, effective and reliable in coalmining-based cities ecosystem classification. As attributive recognition theory can success fully resolve certain issues with a number of fuzzy attribution in comprehensive evaluation, its confidence criterion is established on the basis of the ordered evaluation sets, consequently it will make the evaluation results more reliable.

1. Instruction

In recent years, social economy has been developing rapidly in China, and has made great achievements, while Chinese urbanization has also entered a rapid development period. The rapid development of modern inevitably promotes urbanization, and major urban development strategies are drawn up in the 20th century. During urbanization, urban ecosystem will be destructed. According to the ecology theory, urban ecosystem is composed by natural, social, economic and other factors, but also is the most complex ecosystem influenced by human disturbance and human factors (Shuang-shuang et al., 2012).

When speeding up urbanization, how to maintain the sustainable development of coalmining-based cities ecosystems, that is a problem on which scholars have made related research from different angles. Urban cities ecosystem is a complex system and an inseparable whole, its healthy development is also worth studying, and some scholars have begun some preliminary studies, especially in water quality (Wu and Chau, 2006; Chau, 2007). Spiegel et al. (2011) explored the health concepts of urban ecosystem and constructed the evaluation index system by the driving force–pressure–state–response model. Based on the complex ecosystem theory, Hu et al. (2005) constructed the complex ecosystem health evaluation model to evaluate the development level and coordination degree of urban ecosystem. Muttil and Chau (2007) selected ecologically significant input variables by two extensively used ML techniques, artificial neural networks (ANN) and genetic programming (GP). Zhao et al. (2006) presented a new methodology of multiple criteria data envelopment analysis to make the environmental impact assessment (EIA) of large development projects. Coalmining-based cities ecosystem is a complex large system, its evaluation has not yet formed a unified evaluation criteria and methods, and needs to be explored (Van Oudenhoven et al., 2012; Qiong, 2012). This article builds the evaluation indicators system of coalmining-based cities ecosystem by the field survey, expert seminars and literature, etc. Because the chosen evaluation indicators system is mainly quantitative which are difficult to quantify, in order to make full advantage of the expertise and reduce the arbitrariness, the weights of the indicators are determined by the Analytic Hierarchy Process (abbreviation, AHP).

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Table 1
The evaluation indicators system and evaluation criteria demarcation point.

	Indicators	Unit	Evaluation criteria demarcation point					Weights
			First	Second	Third	Fourth	Fifth	
Vitality I_1	GDP per capita (I_{11})	Ten thousand yuan	12	10	5	3	0.7	0.0329
	GDP growth (I_{12})	%	15	12	10	7	5	0.0338
	The actual utilization of foreign capital (I_{13})	One hundred million dollars	100	90	60	40	10	0.0453
	Per capita disposable income (I_{14})	Ten thousand yuan	2.0	1.6	1.2	0.8	0.4	0.0354
Structure I_2	Proportion of the tertiary industry in GDP (I_{21})	%	80	70	60	40	20	0.0427
	The proportion of high-tech industry in total industrial output value(I_{22})	%	40	35	30	25	20	0.0341
	Financial technology spending (I_{23})	%	9	7	5	3	1	0.0344
	Urbanization (I_{24})	%	50	45	40	35	30	0.0356
	Unemployment rate in urban population (I_{25})	%	2.5	3	3.5	4.5	5.5	0.0356
	Green coverage (I_{26})	%	50	40	30	25	20	0.0325
	Forest coverage (I_{27})	%	50	45	40	35	30	0.0369
	Per capita public green area (I_{28})	m^2	20	16	10	7	4	0.0338
Resilience I_3	Proportion of environmental investment in GDP (I_{31})	%	5	3	2	1.5	1	0.0331
	City life garbage treatment rate (I_{32})	%	100	90	70	50	40	0.0314
	Environmental noise standard area coverage (I_{33})	%	100	95	90	80	70	0.0362
	Industrial wastewater discharge compliance rate (I_{34})	%	100	95	90	80	70	0.0396
	Comprehensive utilization of industrial solid waste (I_{35})	%	100	90	70	50	30	0.0352
	Proportion of education expenditure in GDP (I_{36})	%	5.5	4.5	4	3.5	2	0.0362
Service functions I_4	Engel coefficient (I_{41})	%	30	35	40	45	50	0.0353
	Per capita housing area (I_{42})	m^2	30	27	25	20	17	0.0351
	Per capita road area (I_{43})	%	28	20	15	10	5	0.0369
	Average of traffic noise (I_{44})	Decibel	50	55	65	80	100	0.0346
	Percentage of days with good air quality (I_{45})	%	90	85	80	75	60	0.0403
	drinking water compliance rate (I_{46})	%	98	92	90	85	80	0.0348
Health status I_5	Life expectancy (I_{51})	Years	80	75	70	68	65	0.0339
	The natural population growth rate (I_{52})	‰	1.2	2.4	4	4.5	5.5	0.0334
	The city's population average education years (I_{53})	Year	14	11	9	7	5	0.0349
	Number of higher education per thousand (I_{54})	Number	800	650	450	300	150	0.0361

Note: GDP denotes gross domestic product.

As attributive recognition theory can success fully resolve certain issues with a number of fuzzy attribution in comprehensive evaluation, its confidence criterion is established on the basis of the ordered evaluation sets, this article will evaluate coalmining-based cities ecosystem by the attribute mathematics through setting the evaluation criterion (Dong and Zong, 2005).

2. The evaluation indicators system of coalmining-based cities ecosystem

2.1. The construction of indicators system

At present, the evaluation indicators system of coalmining-based cities ecosystem failed to form a consistent standard in the academic community, but it must be able to accurately reflect the ecological status of the coalmining-based cities (Yan, 2007). Coalmining-based cities is a integrated ecosystem combined with human, environmental, economic, coal, safety, health and society, and each city has different characteristics, so the evaluation indicator system must fit the actual situation of various cities (Su and Fath, 2012).

The literatures (Grimm and Redman, 2004; Wilson et al., 2003; Cadenasso et al., 2007) better summarize the key elements of coalmining-based cities ecosystem and construct the evaluation indicators system, but focus on the elements or local. They are effective within a specific range, but can't truthfully explain the integrity of coalmining-based cities ecosystem, don't reflect the interaction and contact between elements, and can't competent in the study of coalmining-based cities ecosystem. In order to taken into account the possibility of access to information and cannot be divorced from reality and hypothetical indicators, based on the actual situation of Huainan City ecosystem and the associated data acquisition, the evaluation indicators of natural ecosystems are applied into the evaluation of coalmining-based cities ecosystem, the evaluation indicators system of coalmining-based cities ecosystem is composed by the vitality, structure, resilience, service functions and population health status and so on five factors, each factor has