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Environmental Study on Mining Area Living Environment Satisfaction Evaluation-Taking an Example of Huainan City

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Abstract

At the same time, the environmental and health impacts of mining on surrounding communities have been major concerns to governments, the general public and stakeholder organizations and individuals. Mining area residents living environment satisfaction has a close correlation with mining area residents' actual needs. In order to rationally evaluate living environment satisfaction situation on mining area residents, the measure index system were constructed and an attribute mathematical evaluation model was set up. The weights of the indexes were determined by the AHP, and coal mining area residents living environment satisfaction was evaluated by setting the confidence rule according to the attribute measure values of each indicator and multiple indicators. A practical case examines this method's validity. The evaluation results indicated that the attribute mathematical model is an effective method for mining area residents living environment satisfaction evaluation, which provides a relatively scientific and rational evaluation tools for solving such problems.

Keywords: mining area residents, living environment, satisfaction evaluation, attribute mathematics, environmental hazards

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INTRODUCTION

Mining area residents living environment satisfaction is the satisfaction degree of the mining area residents work units and reflects mining area residents' life quality and the humanity degree of human resources management, affects mining area residents' healthy and work attitude (Temelova and Dvorakova 2012).

Mining area residents living environment satisfaction has a close correlation with mining area residents' actual needs, the human nature theory in the human resources management and the behavioral science suggests that the needs of people are complex and diverse (Moos 2012). Mining area residents in the actual work will produce the requirements and expectations which are the main factors of living environment satisfaction. Living environment also produce the requirements and expectations for mining area residents based on environment characteristics and development (Mohi et al. 2010). This phenomenon is the manifestation of the psychological contract, and is combined by the environment protection and the residents' characters.

The study on mining area residents living environment satisfaction helps mining area managers to scientifically develop the ecological environment management system, develop a comfortable living environment, and enhance the quality of living environment (Ibem and Amole 2013). Mining area managers can timely diagnosis the problems of living environment according to the evaluation results, analyze the negative impaction factors, and proposes the effective and reasonable solutions to protect living environment and improve living environment (Zhang et al. 2012). This article builds the mining area residents living environment satisfaction evaluation indicator system by the field survey, expert seminars and literature, etc. The weights of the indicators are determined by the AHP. According to the measure results of indexes, this article sets the confidence criterion to evaluate mining area residents living environment satisfaction degree using the attribute mathematics (Ma et al. 2012, Zhang et al. 2012).

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Table 1. The evaluation indicators system

Target layer	Level indicators	Secondary indicators
The evaluation index of residents living environment satisfaction	safety	crime rate
		security situation
		traffic safety
		disasters publicity and management
	health	air pollution
		waste disposal rate
		noise conditions
		drinking water standards
	convenience	educational facilities condition
		medical facilities condition
		shopping facilities condition
		recreation condition
		children's playground condition
	travel satisfaction	transport facilities
		transportation convenience
		traffic congestion
		daily travel
	comfort	greening rate
		park and green spaces condition
		building density
		building height
		Cleanliness
		public open space conditions
		community culture
		community atmosphere

From the behavioral science theory, the impact factors of mining area residents living environment satisfaction include various factors, and also include the mining area residents' own factors, these factors always influence mining area residents living environment satisfaction (Buys and Miller 2012). This article constructs the evaluation index system of mining area residents living environment satisfaction including five first indicators and 25 secondary indicators, as shown in **Table 1**. Combined with the actual needs of the evaluation process, this article sets five levels of mining area residents living environment satisfaction through the study of the existing literature, they are first, second, third, fourth and fifth, and corresponding level names are "very satisfied, satisfied, general dissatisfied and very dissatisfied".

METHODS

Let X be the evaluation targets space of mining area residents living environment satisfaction. Each element x of X should measure m indicators. The evaluation sets of X's element are I, and C is the satisfaction degree or evaluation category. Each indicator's measure value is digital, the evaluation standards are shown in **Table 2**, which is the single factor grading table.

Supposing the evaluation value of the I_j in sets x is t_j, therefore, x is an m-dimensional vector $x = (t_1, t_2, \cdots, t_m)^T$. The degree of a single indicator value$t_j$can be determined by **Table 2**, but how to evaluate x with m indicator values?

The certain evaluation of elements in the X is named the attribute space or evaluation space F, and the evaluation set$(C_1, C_2, \cdots, C_K)$ is named the division of attribute space or evaluation space F, C_k is named the attribute set or the appraisal rank or the appraisal class. The degree C_k of object x of mining area residents living environment satisfaction is indicated by the attribute measure $\mu_{xk} = \mu(x \in C_k)$, the indicator value t_j of object x is indicated by the attribute measure μ_{xjk}.

μ_{xk} and μ_{xjk} should meet:

$$\mu_{xk} \geq 0, \sum_{k=1}^{K} \mu_{xk} = 1 \quad (1)$$

$$\mu_{xjk} \geq 0, \sum_{k=1}^{K} \mu_{xjk} = 1 \quad (2)$$

The attribute mathematical model of mining area residents living environment satisfaction should solve three evaluation issues: the single indicator attribute measure μ_{xjk}, the attribute measure μ_{xk}, the degree of μ_{xk}.

Single Indicator Attribute Measure Analysis

Assume that the j-th indicator value of x is t, determine the single indicator attribute measure function $\mu_{xjk}(t)$ by **Table 2**.

In **Table 2**, a_{jk} meets $a_{j0} < a_{j1} < \cdots < a_{jK}$ or $a_{j0} > a_{j1} > \cdots > a_{jK}$, the former is taken.

Assume

$$b_{jk} = \frac{a_{jk-1} + a_{jk}}{2}, k = 1,2,\cdots,K \quad (3)$$

$$d_{jk} = min(|b_{jk} - a_{jk}|, |b_{jk+1} - a_{jk}|), k = 1,2,\cdots,K-1 \quad (4)$$

The single indicator attribute measure function $\mu_{xjk}(t)$ is

Table 2. Single index classification table

Degree indicators	C_1	C_2	⋯	C_K
I_1	$a_{10} - a_{11}$	$a_{11} - a_{12}$	⋯	$a_{1K-1} - a_{1K}$
I_2	$a_{20} - a_{21}$	$a_{21} - a_{22}$	⋯	$a_{2K-1} - a_{2K}$
⋯⋯				
I_m	$a_{m0} - a_{m1}$	$a_{m1} - a_{m2}$	⋯	$a_{mK-1} - a_{mK}$

Table 3. The living environment satisfaction evaluation indicator and data

	indicators	satisfaction degree (%)					weights
		first	second	third	fourth	fifth	
safety I_1	crime rate (I_{11})	28	20	12	25	15	0.0591
	security situation (I_{12})	20	41	5	10	14	0.0438
	traffic safety (I_{13})	37	19	16	18	10	0.0453
	disasters publicity and management (I_{14})	30	27	16	10	17	0.0354
health I_2	air pollution (I_{21})	30	21	20	18	11	0.0575
	waste disposal rate (I_{22})	41	27	18	10	4	0.0341
	noise conditions (I_{23})	31	35	25	9	0	0.0344
	drinking water standards (I_{24})	29	38	8	15	10	0.0556
convenience I_3	educational facilities condition (I_{31})	23	20	10	18	29	0.0331
	medical facilities condition (I_{32})	29	23	30	10	8	0.0314
	shopping facilities condition (I_{33})	24	28	30	6	12	0.0362
	recreation condition (I_{34})	10	7	38	25	20	0.0597
	children's playground condition (I_{35})	24	26	20	21	9	0.0554
travel satisfaction I_4	transport facilities (I_{41})	15	9	26	27	23	0.0353
	transportation convenience(I_{42})	7	19	4	50	19	0.0351
	traffic congestion (I_{43})	13	25	11	30	21	0.0369
	daily travel (I_{44})	15	21	8	29	27	0.0346
comfort I_5	greening rate (I_{51})	15	10	26	28	21	0.0339
	park and green spaces condition (I_{52})	20	27	11	19	23	0.0334
	building density (I_{53})	4	21	10	35	30	0.0349
	building height (I_{54})	21	23	17	20	19	0.0361
	cleanliness(I_{55})	17	25	11	28	19	0.0356
	public open space conditions (I_{56})	25	23	20	18	14	0.0325
	community culture (I_{57})	10	28	24	13	25	0.0369
	community atmosphere(I_{58})	5	18	12	38	27	0.0338

$$\mu_{xj1}(t) = \begin{cases} 1, & t < a_{j1} - d_{j1} \\ \dfrac{\left|t - a_{j1} - d_{j1}\right|}{2d_{j1}}, & a_{j1} - d_{j1} \le t \le a_{j1} + d_{j1} \\ 0, & a_{j1} + d_{j1} < t \end{cases} \quad (5)$$

$$\mu_{xjK}(t) = \begin{cases} 1, & a_{jK-1} + d_{jK-1} < t \\ \dfrac{\left|t - a_{jK-1} + d_{jK-1}\right|}{2d_{jK-1}}, & a_{jK-1} - d_{jK-1} \le t \le a_{jK-1} + d_{jK-1} \\ 0, & t < a_{jK-1} - d_{jK-1} \end{cases} \quad (6)$$

$$\mu_{xj1}(t) = \begin{cases} 0, & t < a_{jk-1} - d_{jk-1} \\ \dfrac{\left|t - a_{jk-1} + d_{jk-1}\right|}{2d_{jk-1}}, & a_{jk-1} - d_{jk-1} \le t \le a_{jk-1} + d_{jk-1} \\ 1, & a_{jk-1} + d_{jk-1} < t < a_{jk} - d_{jk} \\ \dfrac{\left|t - a_{jk} - d_{jk}\right|}{2d_{jk}}, & a_{jk} - d_{jk} \le t \le a_{jk} + d_{jk} \\ 0, & a_{jk} + d_{jk} < t \end{cases} \quad (7)$$

From the above structure, for any t, $\mu_{xjk}(t)$ meets the relationship (2).

Multi-indicator Overall Attribute Measure

Each indicator plays different role on the evaluation of mining area residents living environment satisfaction evaluation, therefore, we assume that the weight of the j-th indicator I_j isw_j, w_j meets

$$w_j \ge 0, \sum_{j=1}^{m} w_j = 1 \quad (8)$$

The multi-indicator overall attribute measure μ_{xk} can be gotten by the weight w_j and the single indicator attribute measure $\mu_{xjk}(t)$,

$$\mu_{xk} = \sum_{j=1}^{m} w_j \mu_{xjk} \quad (9)$$

According to the equation (2), (8) and (9), the μ_{xk} meets (1).

Attribute Identification Analysis

The purpose of attribute identification analysis is to make an judgment on the degree of x by the attribute measure $\mu_{xk}(1 \le k \le K)$. So, the paper sets a judgment criterion.

Confidence criterion: Assume that $(C_1, C_2, \cdots, C_K)$ is an order division,

$C_1 > C_2 > \cdots > C_K$,λ is the confidence. $0.5 < \lambda \le 1$.

If $k_0 = \min\{k \left| \sum_{i=1}^{k} \mu_{il} \ge \lambda, 1 \le k \le K \right.\}$

Then, the sample x_i belongs to the kind C_{k_0}.

APPLICATION

This article takes a mining area in Huainan City as the survey. According to the specific situation of this mining area residents living environment, this article selects 28 indicators (**Table 3**) to evaluate this mining

Table 4. The attribute measure value of the second degree single indicators

degree	I_{11}	I_{12}	I_{13}	I_{14}	I_{21}	I_{22}	I_{23}	I_{24}	I_{31}	I_{32}	I_{33}	I_{34}	I_{35}
first	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00
second	0.00	1.00	0.00	0.75	0.00	0.00	1.00	0.80	0.00	0.73	0.20	0.30	0.90
third	0.80	0.00	0.30	0.25	0.90	0.28	0.00	0.00	0.86	0.27	0.80	0.70	0.10
fourth	0.20	0.00	0.70	0.00	0.10	0.72	0.00	0.00	0.14	0.00	0.00	0.00	0.00
fifth	0.00	0.00	000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
degree	I_{41}	I_{42}	I_{43}	I_{44}	I_{51}	I_{52}	I_{53}	I_{54}	I_{55}	I_{56}	I_{57}	I_{58}	
first	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	
second	0.20	0.12	0.50	0.80	0.00	0.00	0.70	0.26	0.28	0.88	0.70	0.72	
third	0.80	0.88	0.50	0.20	0.74	0.58	0.30	0.74	0.72	0.00	0.30	0.28	
fourth	0.00	0.00	0.00	0.00	0.26	0.42	0.00	0.00	0.00	0.00	0.00	0.00	
fifth	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	

Table 5. The attribute measure value of the first degree indicators and overall indexes

index	degree				
	first	second	third	fourth	fifth
I_1	0.2301	0.4712	0.1865	0.0975	0.0147
I_2	0.1518	0.2631	0.4238	0.1003	0.0610
I_3	0.1797	0.4221	0.2478	0.0890	0.0614
I_4	0.1923	0.3102	0.2869	0.1436	0.0670
I_5	0.2109	0.4076	0.1354	0.1342	0.1119
I	0.2231	0.3779	0.1949	0.1040	0.1001

area residents living environment satisfaction degree, determines each index weights by the AHP in **Table 3**.

This article gets the first-hand indicator data of this mining area residents living environment by the field survey, expert seminars and literature, etc. All are shown in **Table 3**.

Compute the attribute measure value of the second degree single indicators by using equations from (3) to (7), as shown in **Table 4**.

RESULTS

Compute the attribute measure value of the first degree indicators and overall indexes by using equations (8) and (9), as shown in **Table 5**.

Take the confidence level; the following conclusions can be obtained according to the confidence criterion.

(1) From the last line in **Table 5**, we can analyze that the overall satisfaction rating is "satisfactory", which can reflect that this mining area residents living environment needs to be improved. In fact, there are some contradictions in this mining area living environment management and other aspects by the interviews, surveys and discussions with mining area managers and ordinary residents, the cohesion is not very strong, residents frequently move.

A certain extent, the paper concludes accord with the actual situation of mining area residents living environment.

(2) From **Table 4**, 11 indicators are "very satisfied" or "satisfied" in the selected 25 evaluation indicators, almost 48%, that indicates that this mining area residents living environment satisfaction is quite comprehensive, but there are also a lot of inadequacies need to be improved.

(3) In **Table 4**, several indexes whose measure value is higher, they are security situation, disasters publicity and management, noise conditions, children's playground condition, public open space conditions. The data show that the mining area residents satisfy with those indexes. But there are still some indicators whose measure value is lower, this mining area living environment management need to be adjusted according to those indicators and focus on improvements in these areas.

(4) From **Table 5** (the attribute measure value of the first degree indicators), safety is the satisfaction level, health is the general level, convenience is the satisfaction level, travel satisfaction is the satisfaction level, and comfort is the satisfaction level.

CONCLUSIONS

In as much as we acknowledge the economic benefits of mining activities in Ghana, there is the need also to recognize the environmental and health hazards that come with it in order to find ways of dealing with them. This article determines the weights of the indexes by the AHP, promotes the evaluation method of mining area residents living environment satisfaction by the attribute mathematics, and applies the method to evaluate a mining area living environment in Huainan

City, computes the attribute measure values of each indicator, and evaluates the satisfaction degrees according to the setting the confidence rule. The evaluation results indicate that the attribute mathematical model is an effective method for mining area residents living environment satisfaction evaluation provides a relatively scientific and rational evaluation tools for solving such problems.

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