

# A Comprehensive Assessment to campus security Based on Grey Cluster

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## Abstract

Based on the existing assessment theory and model, a new campus security model is structured. Then use this model to evaluate campus security of four universities in Hebei province. The results showed that the model, based on grey cluster, not only could confirm the quality degree of every evaluation object but also could assess more objects at the same time and make comparison between different evaluation objects for campus security evaluation. That is mean grey cluster is feasible and instructive.

**Keywords:** campus security, Assessment, Grey cluster

## 1. INTRODUCTION

Now the research on evaluation of campus security is mainly about index system construction and evaluation method. This paper constructs the campus safety evaluation system, which included four aspects: The surrounding environment, campus environment, accident prevention and accident treatment. Then campus security is assessed by grey cluster [1-2], which directly reflects the indicators the pros and cons and provides support for campus security scientific decision-making.

## 2. PRINCIPLE OF INDEX SYSTEM DESIGNING

Indexes system assessing campus security should be based on the above concepts and features. They are indicators collection which can comprehensively, systematically and briefly reflect the conditions of campus security. We should comply with the following five principles when we design them [3].

### A. Scientificity

Evaluation indexes of campus security should fully reflect and embody the meaning of campus security. From a scientific point, users can systematically and accurately analyze and grasp the essence of campus security.

### B. Generality

Evaluation indexes system of campus security should be relatively completely, it means that, indexes system as a whole should basically reflect the main aspects or features of campus security, rather than unrelated branches.

### C. Feasibility

Indexes of campus security can be quantified. These indicators should not be too complicated to calculate and the required data are not only easier to gain but also basically reliable.

### D. Guidance

Indexes system of campus security can not only guide but also lead and drive campus security in a certain degree.

### E. Independence

It refers that all indicators included in the indexes system of campus security should be unrelated and independent with each other. Then on one hand indexes system has clearer structure, on the other hand, indicators indexes system can be ensured to be analysed separately.

### 3. CONSTRUCTION OF INDEXES SYSTEM

According to the idea of basic principle of construct indexes system, indicator system follows ‘system-targets- indexes’ three-level framework structure [4] the model of campus security can consist of 3 hierarchy, 4 sub-system and 18 indicators (Tab1).

The first is system-level, namely evaluation system of campus security. Second is target-level, namely four dimensions including surrounding environment, campus environment, accident prevention and accident treatment. Third is concrete evaluation index of every target-level.

These indicators were got by literature polymerization [5-13]. We divide these indicators into four categories: Surrounding environment (B1), Campus environment (B2), Accident prevention (B3) and Accident treatment (B4). They together express campus security (A). Surrounding environment includes quality of residents (X11) and order situation (X12). Campus environment includes medical standards (X21), fire-fighting facilities (X22), campus traffic (X23), food safety (X24), network Security (X25) and students psychological quality (X26). Accident prevention includes squeeze riding accident prevention (X31), construction accident prevention (X32), sports injury prevention (X33), poisoning prevention (X34), fire accident prevention (X35) and campus traffic accident prevention (X36). Accident treatment includes rescue capacity (X41), evacuation capability (X42), information dissemination (X43) and material support (X44).

information dissemination (X43) and material support (X44) (Tab1).

Tab 1: Evaluation system of campus security

System	Targets	Indexes
Evaluation system of campus security (A)	surrounding environment (B <sub>1</sub> )	quality of residents (X <sub>11</sub> )
		order situation (X <sub>12</sub> )
	campus environment (B <sub>2</sub> )	medical standards (X <sub>21</sub> )
		fire (fighting facilities) (X <sub>22</sub> )
		campus traffic (X <sub>23</sub> )
		food safety (X <sub>24</sub> )
		network Security (X <sub>25</sub> )
		students psychological quality (X <sub>26</sub> )
	accident prevention (B <sub>3</sub> )	squeeze riding accident prevention (X <sub>31</sub> )
		construction accident prevention (X <sub>32</sub> )
		sports injury prevention (X <sub>33</sub> )
		poisoning prevention (X <sub>34</sub> )
		fire accident prevention (X <sub>35</sub> )
		campus traffic accident prevention (X <sub>36</sub> )
	accident treatment (B <sub>4</sub> )	rescue capacity (X <sub>41</sub> )
		evacuation capability (X <sub>42</sub> )
		information dissemination (X <sub>43</sub> )
		material support (X <sub>44</sub> )

#### 4. ASSESSMENT MODEL

To fully assess the development of the system, multi-indicator comprehensive assessment methods are adopted. Author makes use of grey cluster in this paper. Fix grey cluster is very applicable to assess this system.

Suppose  $n$  objects,  $m$  indicators and  $k$  grey classes, the sample observation  $x_{ij}$  means that object  $i$  is about the indicator  $j(i=1,2,\dots,n; j=1,2,\dots,m)$ . We must assess object  $i$  in the light of  $x_{ij}$ , and concrete steps are as follows:

Step 1: divided grey classes  $k$  assessment requirements, and range of indicator is divided into  $s$  grey classes.

Step 2: define indicator  $j$  and  $k$  subclass whitenization weight function:  $f_j^k(\bullet)$ . If the sample observation of object  $j$  is  $x_{ij}$ , then membership function  $f_j^k(x_{ij})$  can be got by whitenization weight function. Specific forms are as follows:

1. Lower measure whitenization weight function:

$$f_j^k(x_{ij}) = \begin{cases} 0, & x_{ij} \notin [0, x_j^k(4)] \\ 1, & x_{ij} \in [0, x_j^k(3)] \\ \frac{x_j^k(4) - x_{ij}}{x_j^k(4) - x_j^k(3)}, & x_{ij} \in [x_j^k(3), x_j^k(4)] \end{cases}$$

2. Upper measure whitenization weight function:

$$f_j^k(x_{ij}) = \begin{cases} 0, & x_{ij} < x_j^k(1) \\ \frac{x_j^k(4) - x_{ij}}{x_j^k(4) - x_j^k(3)}, & x_{ij} \in [x_j^k(1), x_j^k(2)] \\ 1, & x_{ij} \geq x_j^k(2) \end{cases}$$

3. Moderate measure whitenization weight function:

$$f_j^k(x_{ij}) = \begin{cases} 0, & x_{ij} \notin [x_j^k(1), x_j^k(4)] \\ \frac{x_{ij} - x_j^k(1)}{x_j^k(2) - x_j^k(1)}, & x_{ij} \in [x_j^k(1), x_j^k(2)] \\ \frac{x_j^k(4) - x_{ij}}{x_j^k(4) - x_j^k(2)}, & x_{ij} \in [x_j^k(2), x_j^k(4)] \end{cases}$$

In the function,  $x_j^k(1), x_j^k(2), x_j^k(3)$ ,  $x_j^k(4)$  is turning point of  $f_j^k(\bullet)$ .

Step 3: determine each indicator cluster weight  $\eta_j$  and then by membership function  $f_j^k(x_{ij})$  and cluster weight  $\eta_j$ , we can calculate comprehensive cluster coefficient:

$$\sigma_i^k = \sum_{j=1}^m f_j^k(x_{ij}) \eta_j$$

In the end, we think object  $i$  is belong to grey classes  $k^*$  because of  $\max_{1 \leq k \leq s} \{\sigma_i^k\} = \sigma_i^{k^*}$ .

#### 5. ASSESSMENT OF CAMPUS SECURITY

According to the index which established in this paper and making use of grey cluster method, we can assess campus security of four universities in Hebei province.

##### 5.1. Use AHP to estimate the relative weights

The analytic hierarchy process (AHP) was first introduced by Saaty in 1971 to solve the scarce resources allocation and planning needs for the military (Saaty, 1980) [14]. Since its introduction, the AHP has become one of the most widely used multiple-criteria decision-making (MCDM) methods, and has been used to solve unstructured problems in different areas of human needs and interests, such as political, economic, social and management sciences.

Comparison matrices give compare significance between two indicators. In order to determine the quantitative matrices, we use Saaty Tab 1-9 marks.

By Tab 2, we can construct fuzzy comprehensive evaluation matrices: A, B1, B2, B3, B4, as it can be seen from Tab 3 to Tab 7. Then we count max Eigen value and eigenvectors, and normalized eigenvectors. In the end, we get weights of every hierarchy.

Tab 2: Demarcating matrix method.

Demarcating	meaning
1	Equally strong
3	Moderately strong
5	Intermediate strong
7	Very strong
9	Extremely strong
2, 4, 6, 8	Between two marks
countdown	Compare Indicator I with j to get $b_{ji}$ , then compare indicator j with I to $b_{ji}=1/b_{ij}$

Tab 3: Matrix A

A	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	weight
B <sub>1</sub>	1	1/3	1/4	1/3	0.1617
B <sub>2</sub>	3	1	4	3	0.3423
B <sub>3</sub>	4	1/4	1	3	0.2666
B <sub>4</sub>	3	1/3	1/3	1	0.2294

Tab 4: Matrix B1

B <sub>1</sub>	X <sub>11</sub>	X <sub>12</sub>	weight
X <sub>11</sub>	1	1/4	0.3543
X <sub>12</sub>	4	1	0.6457

Tab 5: Matrix B2

B <sub>2</sub>	X <sub>21</sub>	X <sub>22</sub>	X <sub>23</sub>	X <sub>24</sub>	X <sub>25</sub>	X <sub>26</sub>	weight
X <sub>21</sub>	1	1/3	3	1/4	5	3	0.1652
X <sub>22</sub>	3	1	4	1/4	5	7	0.2229
X <sub>23</sub>	1/3	1/4	1	1/5	5	7	0.1545
X <sub>24</sub>	4/1	4	1/2	1	5	7	0.2911
X <sub>25</sub>	1/5	5	1/5	1/5	1	4	0.0969
X <sub>26</sub>	1/3	1/7	1/7	1/7	1/4	1	0.0694

Tab 6: Matrix B3

B <sub>3</sub>	X <sub>31</sub>	X <sub>32</sub>	X <sub>33</sub>	X <sub>34</sub>	X <sub>35</sub>	X <sub>36</sub>	weight
X <sub>31</sub>	1	4	1/4	1/4	1/5	1/7	0.0999
X <sub>32</sub>	1/4	1	1/4	1/6	1/5	1/4	0.0845
X <sub>33</sub>	4	4	1	1/5	1/5	4	0.1593
X <sub>34</sub>	4	6	5	1	1/2	3	0.2376
X <sub>35</sub>	5	5	5	2	1	3	0.254
X <sub>36</sub>	7	4	1/4	1/3	1/3	1	0.1647

Tab 7: Matrix B4

B <sub>4</sub>	X <sub>41</sub>	X <sub>42</sub>	X <sub>43</sub>	X <sub>44</sub>	weight
X <sub>41</sub>	1	4	5	4	0.3897
X <sub>42</sub>	1/2	1	3	3	0.2485
X <sub>43</sub>	1/5	1/3	1	1/3	0.1584
X <sub>44</sub>	1/4	1/3	3	1	0.2034

The consistency property of the matrix is then checked to ensure the consistency of judgments in the pair wise comparison. The consistency index (CI) and consistency ratio (CR) are defined as:

$$CR = \frac{CI}{RI} \text{ and } CI = \frac{\lambda_{\max} - n}{n - 1}$$

Where n is the number of items being compared in the matrix, and RI is random index, the average consistency index of randomly generated pair wise comparison matrix of similar size, as shown in Tab 8.

Tab 8: Random index (Saaty, 1980)

N	3	4	5	6	7	8	9
RI	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Calculated CR, five matrices above are 0.0359, 0.1617, 0.0292, 0.0427, and 0.0094, which are content to consistency.

Now we get weights vector: W= {0.0573, 0.1044, 0.0565, 0.0763, 0.0529, 0.0996, 0.0332, 0.0238, 0.0266, 0.0225, 0.0425, 0.0633, 0.0677, 0.0439, 0.0894, 0.0570, 0.0364, 0.0467}

## 5.2. Determine range of grey classes.

By Delphi, we divided level of campus security into three classes: weak status, middle status and strong status, and like-

wise range of indicator is divided into three grey classes(Tab9).

Tab 9: indicator system of campus security .

indicator	Weights %	Level of campus safety		
		weak	middle	strong
X <sub>11</sub>	0.0573	<5	5-8	>8
X <sub>12</sub>	0.1044	<5	5-8	>8
X <sub>21</sub>	0.0565	<5	5-8	>8
X <sub>22</sub>	0.0763	<5	5-8	>8
X <sub>23</sub>	0.0529	<5	5-8	>8
X <sub>24</sub>	0.0996	<5	5-8	>8
X <sub>25</sub>	0.0332	<5	5-8	>8
X <sub>26</sub>	0.0238	<5	5-8	>8
X <sub>31</sub>	0.0266	<5	5-8	>8
X <sub>32</sub>	0.0225	<5	5-8	>8
X <sub>33</sub>	0.0425	<5	5-8	>8
X <sub>34</sub>	0.0633	<5	5-8	>8
X <sub>35</sub>	0.0677	<5	5-8	>8
X <sub>36</sub>	0.0439	<5	5-8	>8
X <sub>41</sub>	0.0894	<5	5-8	>8
X <sub>42</sub>	0.057	<5	5-8	>8
X <sub>43</sub>	0.0364	<5	5-8	>8
X <sub>44</sub>	0.0467	<5	5-8	>8

### 5.3. Data processing

We get the data of campus security about four universities: *F*, *E*, *C* and *D*. The data came from experts scoring. We invited 13 experts, and asked them give score of every indicator, and then we respectively sum and average them. (Tab 10)

Tab 10: Original matrix

Indicators	<i>F</i>	<i>E</i>	<i>C</i>	<i>D</i>
X <sub>11</sub>	7.9653	8.3368	5.4969	8.9365
X <sub>12</sub>	4.6748	5.6841	7.0451	5.0601
X <sub>21</sub>	8.2801	7.8966	8.5541	8.3064
X <sub>22</sub>	5.4881	8.0372	9.1264	8.9405
X <sub>23</sub>	8.7331	7.3617	9.1740	4.9389
X <sub>24</sub>	5.2966	8.7391	4.8932	5.0535
X <sub>25</sub>	7.4547	7.8055	8.3412	6.7682
X <sub>26</sub>	8.7389	7.2594	7.4858	8.6359
X <sub>31</sub>	6.2687	6.8593	8.5531	6.0260
X <sub>32</sub>	7.0440	8.6310	4.5407	6.2697
X <sub>33</sub>	8.9481	8.6453	7.5228	7.5353
X <sub>34</sub>	5.9579	5.4761	7.4139	5.6192
X <sub>35</sub>	8.3078	6.0959	8.9194	5.8882
X <sub>36</sub>	4.9038	7.6208	4.6383	5.8533
X <sub>41</sub>	9.1359	6.1619	7.8455	5.5144
X <sub>42</sub>	7.2831	6.4951	7.6213	6.2562
X <sub>43</sub>	7.0622	8.6065	7.4528	8.4336
X <sub>44</sub>	5.5118	5.9226	5.2779	6.0256

## 6. CONCLUSIONS

Using formula given in Section 4, we can get  $\sigma^k$  as follow(Tab 11)

Tab 11: Three years cluster coefficient

Indicators	$\sigma^1$	$\sigma^2$	$\sigma^3$
<i>F</i>	0.3226	0.3336	0.4516
<i>E</i>	0.0509	0.2582	0.5253
<i>C</i>	0.2180	0.4377	0.3734
<i>D</i>	0.3086	0.2927	0.4453

By  $\max_{1 \leq k \leq s} \{\sigma_i^k\} = \sigma_i^{k^*}$ , we know *F* *E* and *D* are belong to strong level. But they are different in  $\sigma$ . For *F*,  $\sigma^1$  is close to  $\sigma^2$  but is lower to  $\sigma^3$ , which means it has more indicators belong to weak level and

middle level, and need to make more measures to improve campus security.

For E,  $\sigma_1$  is very lower,  $\sigma_3$  is far more larger than  $\sigma_2$  but  $\sigma_1$  which means it has more indicators belong to strong level, which means it is more obvious than other two levels.

For D, it is similar to A, it also need to make more measures to improve campus security.

C is belong to middle level. Further comparing  $\sigma_1$ ,  $\sigma_2$  and  $\sigma_3$ , we know that  $\sigma_2$  is close to  $\sigma_3$  and larger than  $\sigma_1$ , which means it has more features of strong level than that of lower level.

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