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# Evaluation of the Fire Emergency Rescue Capability in Urban Community

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## Abstract

The fire emergency rescue capability in urban community embodies the emergency capability of government. This paper builds the evaluation system and a comprehensive evaluation model to the fire emergency rescue capability in urban community based on the fuzzy analytic hierarchy process. The example shows that the evaluation index system and the model are operational, practical and effective.

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*Keywords:* Urban community, emergency rescue, fire protection, fuzzy analytic hierarchy process

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## 1. Introduction

In recent years, the urban community fire increases dramatically. Therefore, it has been concerned by the government and academia that how to cope with fire emergencies and decrease the loss caused by fire emergencies. Communities are basic social units and its safety is the foundation of people's production and subsistence security. Consequently, emergency rescue of communities plays vital role in the fire emergency response. A number of examples demonstrate that it is an urgent problem to make the fire emergency rescue in urban communities better<sup>[1]</sup>.

Evaluating the emergency rescue capability is the foundation of the emergency management work of urban community fire. It is supposed to build objective and scientific evaluation index as well as normative an evaluation system. Meanwhile, evaluating the fire rescue capability in urban communities should be included in the assessment system of fire departments at all levels. Also, we can evaluate it periodically. If the word was worked, it is necessary to build an evaluation system<sup>[2]</sup> which is scientific, normative, systematic and complement.

It is showed in the academics that the domestic study on the fire rescue capability is not deep-going, which is also not systemic. Also, it is weak to study on how to cope with the fire emergencies in urban communities. According to

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the features of fire hazards, the author, on the basis of the emergency theories, puts forth to the evaluation system of the fire emergency rescue capability in urban community. Furthermore, the author constructs a comprehensive evaluation model to the fire emergency rescue capability in urban community based on the fuzzy analytic hierarchy process as well as check analysis combining with examples.

## 2. The Index System of the Fire Emergency Rescue Capability in Urban Community

In this paper, the fire emergency rescue capability in urban community means to carry out the rescue action efficiently and sequentially after the occurrence of the future fire emergencies so that the death and economic loss could be decreased to the minimum. Also, it refers to the preparation and effort in program formulation, command and coordination, action support and material.

### 2.1. Principles of choosing indexes

Some principles should be followed to build the evaluation system of the fire emergency rescue capability in urban community:

(1)The systematic principle: the fire emergency rescue capability in urban community refers to amounts of factors, so the evaluation index system should evaluate the fire emergency rescue capability comprehensively and objectively.

(2)The succinct principle: The index system should be comprehensive and emphasizes main factors influencing the fire emergency rescue capability in urban community, so that the key advantages of the capability could be found, which will increase the evaluating accuracy.

(3)The principle of combining qualitative and quantitative indexes: Since many factors affecting the fire emergency rescue capability in urban community could not be described by quantitative indexes, it is necessary to build the evaluation system and methods by combining the qualitative and quantitative ways.

### 2.2. The Construction of the Evaluation Index System

It will directly influence the conclusion of this evaluation whether the evaluation index of the fire emergency rescue capability in urban community is appropriate. However, building a perfect evaluation system, which is scientific, reasonable and could reflect the real capability of urban communities, is very difficult. This paper, aiming at the characteristics of urban communities, builds a relatively evaluation system based on those three principles. The fire emergency rescue capability in urban communities consists of “soft capabilities” and “hard capabilities”. “Soft capabilities” include seven levels: ① the warning and monitoring capability of community fire, ② the rescue and command capability of community fire, ③ the emergency rescuer capability of community fire, ④ the rescue volunteer team of community fire, ⑤ the emergency professional capability of community fire, ⑥ the emergency rescue organizations of community fire, ⑦ the emergency rescue preplan of community fire. “Hard capabilities” include three levels: ① the emergency rescue infrastructure of community fire, ② the emergency rescue equipments of community fire, ③ the emergency rescue equipments of community families.

Table I . The Evaluation System of the Fire Emergency Rescue Capability in Urban Community

categories	The first level	The second level
The fire emergency rescue “soft capabilities” in communities	the warning and monitoring capability of community fire	The comprehensive application of warning facilities, the monitoring and forecasting capability of fire hazards
	the rescue and command capability of community fire	The fire emergency rescue command center in communities, the achievement ratio of five-minutes fire controlling time
	the emergency rescuer capability of community fire	the number of rescuer, the educational attainments, the master level of rescuer to rescue facilities, the quick response capability of rescuer
	the rescue volunteer team of community fire	the number of fire emergency rescue volunteer team, the legal safeguard of volunteers, the training of volunteers
	the emergency professional capability of community fire	the personal protecting device of fire emergency rescuers
	the emergency rescue organizations of	the coordinating level of workers in fire emergency organization,

	community fire	the practical level of duties of fire emergency organization
	the emergency rescue pre-arranged plan of community fire	the formulation of the fire emergency pre-arranged plan in communities, the evaluation of the fire emergency pre-arranged plan in communities, the practice of the fire emergency pre-arranged plan in communities
The fire emergency rescue “hard capabilities” in communities	the emergency rescue infrastructure of community fire	the achievements ratio of fire protection roads in communities, the number of fire station in communities, the medical rescue center in communities, the water supply facilities
	the emergency rescue equipments of community fire	the ratio of the fire emergency rescue equipments in communities, the number of fire hydrant in communities, the categories and number of fire emergency rescue cars in communities, the personal protecting device of fire emergency rescuers
	the emergency rescue equipments of community families	the emergency rescue equipments of community families

### 3. Establishing the Evaluation Model of the Fire Emergency Preparation Capability in Urban Community

Since its limitation is not determined in quantity, it is a fuzzy definition which refers to the emergency preparation capability of urban communities. Therefore, we had better describe it in fuzzy language variable and use comprehensive method, FAHP, which combines Fuzzy Mathematics model and AHP model, to evaluate it qualitatively and quantitatively. Thus, the evaluation can reflect the level of the emergency preparation capability of urban community fire veritably<sup>[3-5]</sup>.

#### 3.1 Building factor set $V$ and determine weight of factor set $U$

Determine each factor concerning estimation target, and then constitute one factor set  $V$  :

$$V = (V_1, V_2, \dots, V_n) \tag{1}$$

The sub-factor set  $V_i$  :  $V_i = (V_{i1}, V_{i2}, \dots, V_{in}), i = 1, 2, \dots, n$  (2)

The evaluation factor set of the emergency preparation capability of urban community fire is composed of first-level indexes in Tab. I . The sub-factor set consists of second-level indexes in Tab. I

Fix how to distribute the weight of lower factors relative to upper factors, and then consist of weight set  $U$  . Then in the light of the effect of sub-factors  $U$  :

$$U = (u_1, u_2, \dots, u_m), \sum_{i=1}^n u_i = 1 \tag{3}$$

$$U_i = (u_{i1}, u_{i2}, \dots, u_{im}), u_{ij} \in [0, 1] \sum_{i=1}^n u_i = 1 \tag{4}$$

$u_{ij}$  represents that  $V_{ij}$  occupies the proportion of  $V_i$ ,  $m$  represents the number of second-level indexes of  $V_i$  .

After that, we need to ascertain the weight distribution that the lower level is relative to the upper level. The model applies the Borda approach, inviting 30 emergency management experts and urban community managers to sort each index so that the weight value of each index would be decided according to the importance.

#### 3.2 Building estimation set $F$ and determine estimation matrix $R_i$

The evaluation set is usually called the remark set:  $F = (F_1, F_2, \dots, F_l)$  (5)

Aiming at the characteristics of the fire emergency rescue capability in urban community, we use four levels of standards to divide the fire emergency rescue capability in urban community.  $F_1$ : The fire emergency rescue capability in urban community is very good (fine), which can meet the demands of coping with sudden incidents in urban communities very well.  $F_2$ : The fire emergency rescue capability in urban community is good (standard), which can meet the demands of coping with sudden incidents in urban communities.  $F_3$ : The fire emergency rescue capability in urban community is not bad (clinical).  $F_4$ : The fire emergency rescue capability in urban community is bad (dangerous), which can't meet the needs of coping with sudden incidents in urban communities.

Estimation matrix  $R_i$  is composed of membership grade which each sub-factor  $V_i$  of is relative to each language variable of estimation set  $F$ .

$$R_i = \begin{bmatrix} R_{i1} \\ R_{i2} \\ \dots \\ R_{in} \end{bmatrix} = \begin{bmatrix} r_{i11} & r_{i12} & \dots & r_{i1m} \\ r_{i21} & r_{i22} & \dots & r_{i2m} \\ \dots & \dots & \dots & \dots \\ r_{in1} & r_{in2} & \dots & r_{inm} \end{bmatrix} = (r_{gk})_{n \times m}, \quad i = 1, 2, \dots, n; \quad k = 1, 2, \dots, m \quad (6)$$

$r_{gk}$  represents the membership grade of the  $j$  factor in the  $i$  factor relative to the level of  $k$ .

$$R_i = \begin{bmatrix} R_{i1} \\ R_{i2} \\ \dots \\ R_{in} \end{bmatrix} = \begin{bmatrix} r_{i11} & r_{i12} & \dots & r_{i1m} \\ r_{i21} & r_{i22} & \dots & r_{i2m} \\ \dots & \dots & \dots & \dots \\ r_{in1} & r_{in2} & \dots & r_{inm} \end{bmatrix} = (r_{ik})_{n \times m} \quad (7)$$

In equation (7):  $r_{ik}$  represents the membership grade of the  $i$  factor relative to the level of  $k$ .

According to the features of emergency management in urban communities, we apply expert evaluation method to get the membership of each index. The expert evaluation method is to invite many experts to evaluate the fire emergency rescue capability in urban community on the basis of four grades of estimation set. Then fill the results into expert evaluation tables. Finally calculate fuzzy evaluation set  $R : R(r_1, r_2, r_3, r_4) \cdot r_1 \sim r_4$  is successively membership which indexes are relative to the first to the fourth of evaluation set.

### 3.3 The fuzzy operation and evaluation criterion

$$B = U \circ R = (b_1, b_2, \dots, b_m) \quad (8)$$

$$D = (d_1, d_2, \dots, d_m) \quad (9)$$

$$E = \sum_{k=1}^m b_k^q * d_k / \sum_{k=1}^m b_k^q \quad (10)$$

It can be divided to four grades for the fire emergency rescue capability in urban community, including Fine, Standard, Clinical, Dangerous, the value of which are showed in Table II. The value of E can be operated according to Formula (10), and then the grade of emergency preparation management ability in urban communities can be determined on the basis of Table II.

Table II. The Evaluation System of the Fire Emergency Rescue Capability in Urban Community

Grade	Fine	Standard	Clinical	Dangerous
$E$	$E \geq 85$	$70 \leq E < 85$	$60 \leq E < 70$	$E < 60$

## 4. Example Applying

This paper takes one community as an example in Zhengzhou city, Henan province. Then according to the estimation frame of the fire emergency rescue capability in urban community, we give estimation factor set  $V$  and estimation set  $F$ :

$V = \{V_1(\text{the warning and monitoring capability of community fire}), V_2(\text{the rescue and command capability of community fire}), V_3(\text{the emergency rescuer capability of community fire}), V_4(\text{the rescue volunteer team of community fire}), V_5(\text{the emergency professional capability of community fire}), V_6(\text{the emergency rescue organizations of community fire}), V_7(\text{the emergency rescue pre-arranged plan of community fire}), V_8(\text{the emergency rescue infrastructure of community fire}), V_9(\text{the emergency rescue equipments of community fire}), V_{10}(\text{the emergency rescue equipments of community families})\}$

$$F = \{F_1(\text{fine}), F_2(\text{standard}), F_3(\text{clinical}), F_4(\text{dangerous})\}$$

in the light of experts' opinion, we employ the Borda approach, and determine the weight distribution of estimation index as  $w = (0.107, 0.112, 0.086, 0.114, 0.089, 0.058, 0.121, 0.116, 0.085, 0.112)$ 。

After evaluation from experts, the grade of fine for  $V_1$  accounts 30%. The grade of standard accounts 30%, the clinical accounts 30%, and the dangerous accounts 10%. Thus, we are able to get the estimation vector of  $V_1$  (0.32, 0.3, 0.3, 0.1). Similarly, we could get the estimation vectors of  $V_2 \sim V_{10}$ . We employ fuzzy hierarchy operation and normalization process with average weight principle. Therefore, we choose the estimation weight set  $D = (90, 80, 70, 60)$  and finally get  $E = 81.53$  after calculating. According to the Table I, we can figure that the level of the emergency rescue capability of the community is standard, which could satisfy the emergency need. However, in order to improve its capability, it is supposed to further satisfy and complete the level of all indexes, especially the emergency rescue infrastructure and equipments of community fire.

## 5. Conclusion

1) Estimating the fire emergency rescue capability in urban community is a complex task. And it is very useful for moving forward the construction of safety urban communities to build perfect the evaluation system with scientific method.

2) In the emergency management view, the author builds the evaluation system of the fire emergency rescue capability in urban community which includes ten first-level and twenty six second-level.

3) This paper puts forward the evaluation model of the disaster prevention and reduction of rural communities. The analysis of example shows that it is useful, practical and popular.

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