

Research on the Suitability of the Emergency Shelter in Tianjin

Xuefang Wang^{1, a, *}

¹School of Economics and Management, Beijing Jiaotong University, Beijing, China

^aWangxuefang1945@163.com

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Abstract. Emergency shelter is an important part of the urban public safety system, which plays an important role in coping with emergencies. The research on the suitability of the completed emergency shelter is helpful to understand its shortcomings and optimize the city's emergency shelter capability. Based on the three aspects of effectiveness, safety, and accessibility, this paper selected 9 evaluation factors of the suitability of the emergency shelter, used AHP to determine the index weight, and constructed the evaluation index system. On this basis, the paper applied TOPSIS technology to establish an evaluation model for the suitability of emergency shelter in Tianjin and made a comprehensive evaluation of 28 emergency shelters in Tianjin. The results show that there are 11 emergency shelters in excellent level, 15 in a good level, and 2 in the middle level, and 0 in poor level. The research results can provide some references for emergency management departments to evaluate the suitability of urban emergency shelter site selection and optimize its emergency service capacity.

Introduction

Emergency shelter is an important part of urban emergency resource security. When urban emergencies occur, emergency shelters can quickly integrate resources from all aspects of society to effectively respond to and recover from sudden disasters, thereby effectively reducing the impact and reducing property losses and casualties. Although the construction of emergency shelters in China has achieved great results, there are still many problems. The specific performance is that the distribution of emergency shelters in urban space is uneven, the service capacity is insufficient, the construction of emergency function facilities is relatively lagging, and the site selection is unreasonable, etc.

At present, the suitability evaluation of urban emergency shelters generally includes an assessment of the rationality of planning, spatial layout, site selection and land use of emergency shelters. Huang Dianjian, Wu Zongzhi et al. (2006) applied an analytic hierarchy process to establish a comprehensive evaluation model [1]. Fan Liangxin, Yan Yan, Liu Changhua (2013) applied the analytic hierarchy process and GIS technology, and studied the suitability of the spatial layout of the emergency shelter in the city [2]. Chen Yuhua (2014) used the subjective and objective weighting method combined with the entropy method (AHP) and entropy method and GIS buffer analysis to study the suitability of land for emergency shelters in Guangzhou [3]. Li Yangli, Wang Peiyu, and Cheng Si (2015) used the network analysis method to study the suitability of the layout of fixed emergency shelters in Mianyang City by using the service area ratio and site utilization rate as evaluation indicators. [4]. Shi Xiaorui (2016) used grey relational analysis combined with entropy weighting method to establish a suitability evaluation model, studied the suitability of emergency shelters in Shijiazhuang urban area, analyzed the existing problems and proposed layout optimization [5]. Sun Yuyue, Chen Peng et al. (2017) used the TOPSIS evaluation method to establish a site selection suitability evaluation model, and conducted an empirical study using Daoli District of Harbin as an example [6]. The selection of evaluation indicators is the main basis for measuring the suitability of urban emergency shelters. When selecting evaluation indicators, the domestic and international experience and the predecessors' research and the natural geographical features of the study area should be integrated. Therefore, the ready-made emergency shelter suitability evaluation model is not universal. This paper takes the site suitability of Tianjin Emergency Shelter as the research object. Based on the comprehensive reference to the unique

natural geographical features of the city's river network in Tianjin, the “avoiding geological and hydrological hidden danger points” was introduced into the evaluation index system, and a new evaluation index system suitable for Tianjin emergency shelters was established. The TOPSIS method was used to evaluate the suitability of the site selection of 28 emergency shelters in Tianjin, and the rationality of the site selection was tested.

Evaluation Index Selection and Weight Determination

The selection of evaluation indicators is an important basis for measuring the suitability of urban emergency shelters, and directly reflects the scientific nature of the evaluation model. By studying relevant literatures and integrating the natural geographical features of Tianjin, this paper selects appropriate indicators from three aspects of effectiveness, safety and accessibility, and constructs an index system for the suitability evaluation of Tianjin emergency shelters.

(1) Effectiveness

Effectiveness refers to the supply capacity of emergency shelters in the event of a disaster.

(1.1) emergency evacuation function facility

The construction of emergency shelters' functional facilities directly determines the service capacity of the shelters in the event of a disaster.

(1.2) capacity

The more people can be accommodated in an emergency shelter, the more it can meet the evacuation needs of more people in the event of a disaster, and the more effective it is.

(1.3) per capita refuge area

The area of the shelter determines whether it can provide effective service space for all victims in the service area. The larger the per capita shelter area, the higher the security of the victims entering the shelter.

(2) Security

Safety assurance is the core issue of planning and building emergency shelters. When constructing an emergency shelter, the city shall comply with the principle of safety, avoid major sources of danger, ensure the safety of the emergency shelter itself and the surrounding environment, and minimize the secondary hazard impact of residents during disaster avoidance. This paper comprehensively references the literature and selects the distance from major hazard sources as an important evaluation index. Among them, rivers as an important source of urban hazards that are likely to cause secondary disasters are important evaluation factors in an indicator. According to the unique geographical and natural conditions of Tianjin, this paper separates the “avoiding geological and hydrological hidden danger points” from the major hazard sources that are prone to secondary disasters, and juxtaposes them with “distance from major hazards” as safety criteria.

(2.1) Distance to major hazard sources

The emergency shelter shall be far away from the major dangerous sources such as the inflammable and explosive factory warehouse, gas station, gas supply plant, etc. in the city, otherwise it is easy to cause secondary disasters in the earthquake.

(2.2) Avoid geological and hydrological hidden dangers

Earthquake secondary flooding is highly harmful. It refers to the destruction of terrain or hydraulic structures caused by the earthquake, which leads to flooding, mudslides and other events. Although the probability of occurrence is very low, if it happens, the casualties caused are even higher than the direct disasters of the earthquake. Tianjin is a city with many waters. The city's river network is closed, except for the Haihe River, and the South and North Canals and the Ziya River. In view of the natural and geographical conditions of Tianjin, the government should pay attention to avoiding these geological and hydrological hidden danger points when constructing emergency shelters, and select emergency shelters in areas other than 1000 meters away from the river.

(3) Accessibility.

Accessibility reflects the efficiency of the emergency shelters to communicate with the outside world.

(3.1) Distance from recent medical institutions.

The distance between the emergency shelter and the hospital is the length of the lifeline. The distance is directly related to the speed at which the victims receive medical care.

(3.2) Distance from the recent public security organs.

The distance between the emergency shelters and the nearest police station directly determines the speed of the police station and affects the efficiency of rescue.

(3.3) Distance to the nearest fire base.

The distance between the emergency shelter and the fire station is related to the efficiency of the emergency rescue service. The closer the distance is, the faster and more efficient the emergency shelter can obtain the rescue service.

(3.4) Evacuated road grade.

The higher the level of evacuation roads, the better the traffic accessibility, and the higher the rescue efficiency of each service facility at or after the disaster.

According to the Tianjin City Emergency Refuge Selection Site Suitability Evaluation Index System and AHP Weight Calculation Method, the weight of each indicator is determined by the expert scoring method. By averaging the data of all valid questionnaires, and then constructing the judgment matrix, the weights and consistency test results are finally calculated, as shown in Table 1.

Table1. Evaluation index and weight of suitability of site selection for emergency shelter

Criteria layer factor	Total target weight	Indicator factor	Total target weight
Effectiveness	0.3090	1.Emergency evacuation function facility	0.0618
		2.Capacity	0.0618
		3.Per capita shelter area	0.1854
safety	0.5816	4.Distance to major hazard sources	0.4847
		5.Avoid geological and hydrological hidden dangers	0.0969
Accessibility	0.1094	6.Distance from recent medical institutions	0.0134
		7.distance from the recent public security organs	0.0111
		8.Distance to the nearest fire base	0.0292
		9.evacuated road grade	0.0557

Consistency ratio: 0.0186<0.1

Empirical Analysis

Establishment of the Scoring Layer

According to the suitability evaluation system for emergency shelters in Tianjin, this paper establishes the scoring system of the study area, as shown in Table 2. It is mainly based on the requirements of the “Earth Earthquake Disaster Prevention Planning Standards” and the “Code for Design of Disaster Prevention and Evacuation Sites” and other emergency shelters, as well as relevant expert opinions.

Table 2. Index level grading standard

Indicator layer	Rating value
1.	excellent (5), good (3), poor (1)
2.	0~0.5million (1), 0.5~3million (2),3~10million (3),10million and above (4)
3.	0~3m ² / person (1),3~6m ² / person (3),6m ² / person (5)
4.	0~0.5km (1),0.5~1km (3), 1km and above (5)
5.	0~0.5km (1),0.5~1km (3),1km and above (5)
6.	0~500m (5),500~1000m (3),1000m and above (1)
7.	0~500m (4),500~1000m (3),1000~1500m (2),1500m and above (1)
8.	0~1km (5),1~2km (4),2~3km (3),3~4km (2),4km and above (1)
9.	Freeway (4), Main road (3), Secondary road (2), Branch road (1)

Note: The number in "()" represents the rating of the corresponding rating.

Adaptability Evaluation Based on TOPSIS Method

The decision matrix is constructed according to the index data of the Tianjin Emergency Shelter and the index level grading standards shown in Table 2. According to the TOPSIS evaluation method, weight the normalization of the initial matrix, obtain the positive and negative ideal points of the weighted norm matrix, and then determine the distance between the positive and negative ideal points. The final result is shown in Table 3.

Table 3. Evaluation results of suitability of site selection for emergency shelter

Emergency shelter name	D _i ⁺	D _i ⁻	C _i	grade	Emergency shelter name	D _i ⁺	D _i ⁻	C _i	grade
Central park	0.0303	0.0987	0.7653	excellent	Riverfront Plaza	0.0589	0.0531	0.4743	good
Weinan Park	0.0181	0.1074	0.8559	excellent	Hexi Park	0.0589	0.0531	0.4740	good
Galaxy Square	0.0539	0.0569	0.5137	good	century Square	0.0241	0.1008	0.8071	excellent
People's Park	0.0547	0.0546	0.4994	good	Fuyuanli Square	0.0270	0.1001	0.7876	excellent
Hedong Park	0.0540	0.0569	0.5132	good	Toray Plaza	0.0283	0.0988	0.7777	excellent
Zhongshan Gate Park	0.0521	0.0662	0.5595	good	Wang Chuanchang Park	0.0548	0.0564	0.5074	good
water park	0.0535	0.0576	0.5183	good	Jingu Leisure Park	0.0551	0.0563	0.5057	good
Changhong Park	0.0986	0.0289	0.2263	medium	Peak Park	0.0321	0.0985	0.7542	excellent
Beining Park	0.0543	0.0553	0.5048	good	Xiyuan Park	0.0321	0.0985	0.7542	excellent
Yuhe Park	0.0459	0.0982	0.6817	excellent	Cultural Square	0.0547	0.0565	0.5084	good
Xigu Park	0.1002	0.0284	0.2210	medium	Huacui Park	0.0251	0.1004	0.8002	excellent
Hongqiao Park	0.0579	0.0533	0.4794	good	cultural Square	0.0539	0.0570	0.5137	good
Riverside Park	0.0577	0.0536	0.4814	good	Drum Tower Square	0.0555	0.0542	0.4940	good
Century Square	0.0266	0.1003	0.7907	excellent	Taifeng Park	0.0242	0.1008	0.8062	excellent

According to the results of Table 3, the suitability evaluation level of the emergency evacuation site in Tianjin is 11 excellent emergency evacuations, 15 good, 2 moderate, and 0 poor. The highest

comprehensive score is in Weinan Park. The emergency shelter has a reasonable spatial location, away from major dangerous sources and rivers in the city. It is close to medical, public security and fire-fighting institutions, with high road accessibility and per capita shelter area. The emergency shelters with the lowest scores are Changhong Park and Xiqiao Park, and the emergency evacuation function needs to be further strengthened.

From the perspective of effectiveness, Yuhe Park has the lowest score. The emergency shelter of the emergency shelter has a small area, and the residents have a lower sense of security when they enter the emergency shelter.

From the perspective of safety, Changhong Park and Xiqiao Park scored the lowest. Among them, there are 6 gas stations within 1km of Changhong Park emergency shelter. The nearest gas station with it is only 265m away. Xiqiao park is only 410 meters away from the adjacent Sinopec gas station (Guangrong Road), which is close to the Beijing Hangzhou canal. So its safety is poor.

From the perspective of accessibility, the lowest scores are Peak Park and Xiyuan Park. The distance between the two emergency shelters is relatively far from the medical institutions, public security organs, and firefighting sites. It is difficult to get rescue and command quickly when disasters occur.

Conclusion

The construction of emergency shelter is an important part of urban earthquake prevention and disaster prevention. The suitability of emergency shelter conforms to the characteristics of urban sustainable development. This paper comprehensively refers to the unique physical and geographical characteristics of Tianjin, and puts forward the emergency situation of Tianjin. The evaluation system of evacuation site selection suitability is established, and the evaluation model of evacuation site selection suitability is established by TOPSIS method. This paper studies the applicability of the existing emergency shelters in Tianjin, and points out the shortcomings of the emergency shelters in Tianjin. Through comprehensive analysis, Yuhe park has poor effectiveness in the existing emergency shelters in Tianjin, and other green spaces can be appropriately selected as supplementary resources of the shelters; Changhong Park and Xiqiao park are closer to the risk sources, so emergency response should be strengthened. Prevention work: the accessibility of Gaofeng Park and Xiyuan park is poor. The distance between the two emergency shelters is far from the fire base. Strengthen the fire control work and formulate a scientific and complete fire emergency plan.

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