Assessment of Natural Disaster Mitigation Capability and Key Index at District Level in Shanghai with TOPSIS: A Case Study of Xuhui District

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Abstract

In this work, TOPSIS（Technique for Order Preference by Similarity to an Ideal Solution） is utilized to assess natural disaster mitigation capability in Xuhui District of Shanghai at township level as assessment unit. The capability of the 13 streets and towns in Xuhui district are divided into four levels, "strong", "secondary strong", "medium" and "weak". We analyzed the impact of weight change of the index system on the assessment results. The results show that weight change can change the assessment results, but the changes are not significant. Furthermore, we investigateted the key index that affect the assessment on natural disaster mitigation capability at township level in Xuhui District by simulating various reasonable values and made thematic maps of natural disaster mitigation capability of Xuhui District.

Keywords: Assessment of natural disaster mitigation capability; TOPSIS; Weight change; Key index; Xuhui District; Shanghai

1. Introduction

As the economic center of China, Shanghai is a mega-city with a permanent population of more than 24 million. There are dense various kinds of buildings and major infrastructures. As a coastal city, it is vulnerable to typhoon, rainstorm, waterlogging, storm surge and red tide. In addition, Shanghai is located at the mouth of the Yangtze River, formed by alluvial sediment. As a result, geological disasters such as land subsidence are also prone to occur with the rapid economic development and frequent land reclamation activities. Therefore, it is of great significance to carry out assessment of natural disaster mitigation capability, and then to improve natural disaster mitigation capability. Based on this, the government can make disaster-prevention strategies to minimize casualties and property damage when disaster strikes. Some scholars have also done research on the assessment of natural disaster mitigation capability[1]-[2]. The index system of natural disaster mitigation capability in this work is shown in Table1.

Table1. The index system of natural disaster mitigation capability

First-level indicators	Second-level indicators
Capacity of disaster management	Capacity of team management
	Capacity of assessment of disaster risk
	Capacity of financial investment
Capacity of disaster preparation	Capacity of materials reserves
	Capacity of medical aid
Capacity of self-rescue and transfer	Capacity to help each other
	Capacity of public safety
	Capacity of transfer and resettlement

2. Objective

Taking Xuhui District in Shanghai as the study area, this study explored the impact of weight changes on the assessment results based on the index system of assessment on natural disaster mitigation capability of the First National Survey on Integrated Risk of Natural Disasters in Shanghai. The dynamic change of index is simulated to explore the key index which affects the natural disaster mitigation capability of townships in Xuhui District, so as to provide scientific reference for the improvement path of natural disaster mitigation capability at the district level.

3. Method

TOPSIS is a common intra-group comprehensive evaluation method, which can make full use of the information of the original data, and its results can accurately reflect the gap between the evaluation schemes. This method has no strict limit on data distribution and sample content, and is easy to calculate. The basic calculation process is as follows:

Suppose there are n evaluation objects, and each object has m indicators

1. Construct the normalized initial matrix.
2. Determine the best solution and the worst solution.
3. Calculate the distance between each evaluation object and the best and worst scheme.
4. Calculate and sort the closeness degree between each evaluation object and the optimal scheme.

4. Results

We used TOPSIS to assess natural disaster mitigation capability in Xuhui District at township level as assessment unit with default weights, that is, the weights of each indicator were basically equal, and the results were shown in Figure (a). It can be seen that the level of natural disaster mitigation capability of the 13 streets are divided into "strong", "secondary strong", "medium" and "weak". The number of streets in "medium" is the largest, and the street with the strongest natural disaster mitigation capability is Hunan Street. On this basis, we change the weight of each indicator according to the extreme case. The results of weight changes are shown in Figure(b) - (l). It can be seen that no matter how the weight of each indicator changes, the natural disaster mitigation capability of Hunan Street is basically "strong", while that of Tianlin Street, Xujiahui Street and Caohejing Street are always "weak". The changes of the natural disaster mitigation capability levels of the other streets and towns are also basically among the neighboring levels, and there is no significant rise or decline in the level of natural disaster mitigation capability.

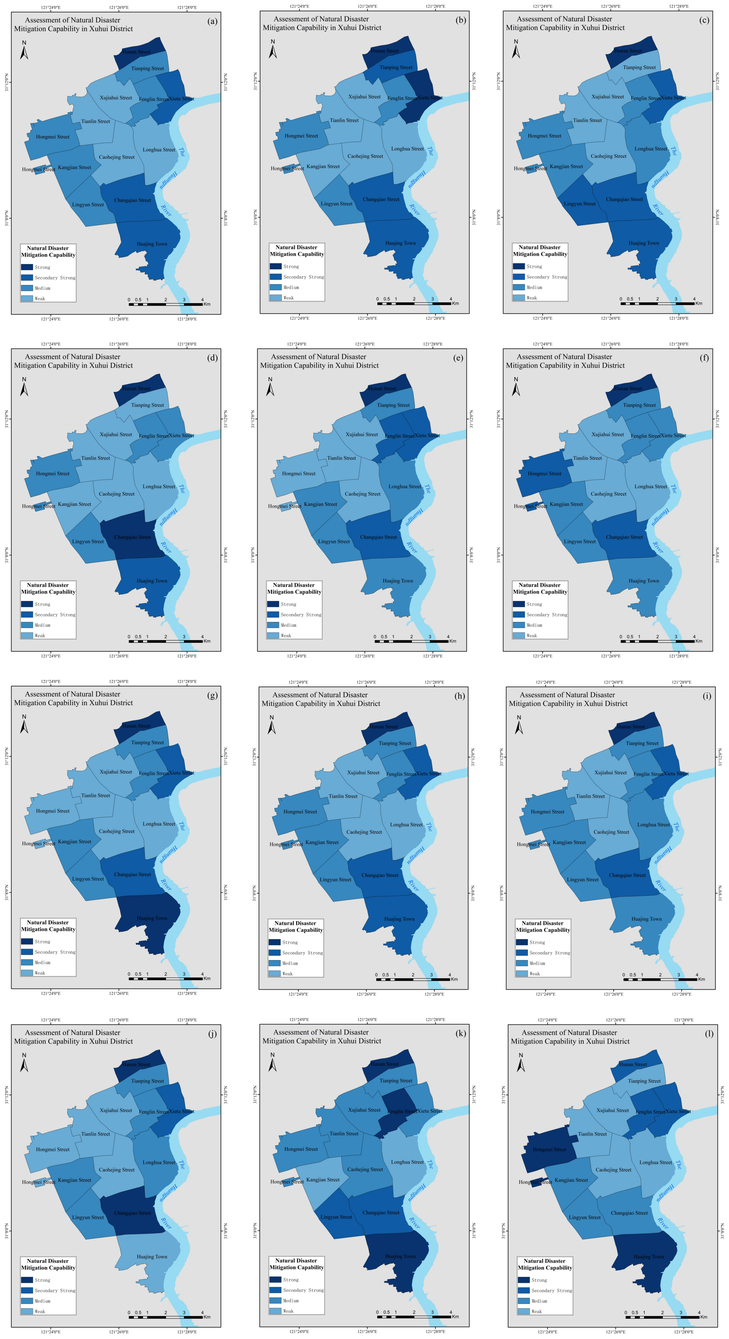

Figure1. (a) Map of the natural disaster mitigation capability in Xuhui District at township level with default weights.
Figure1. (b)-(l) Maps of the natural disaster mitigation capability in Xuhui District at township level with changing weights.

We use the control variates to change the data of each indicator in the four streets with the grade of "weak". Assuming the same amount of money is available, we observe which is more likely to improve the natural disaster mitigation capability of the street by dividing it equally among the indicators or investing it all in one indicator.

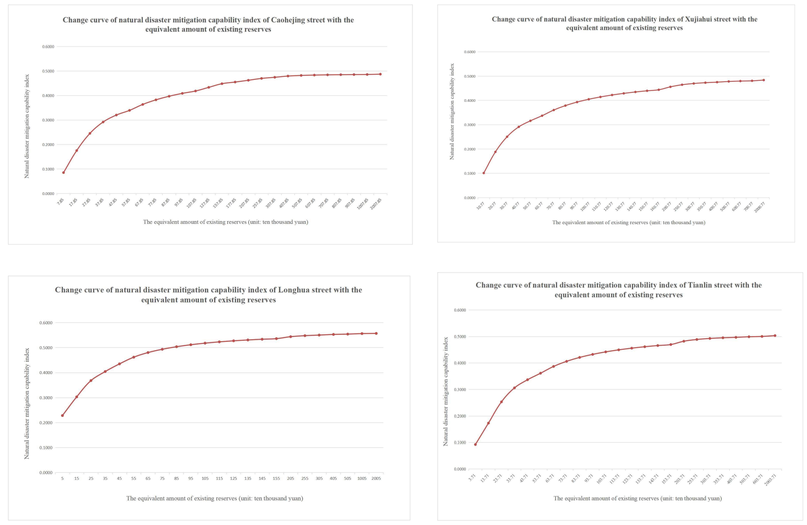

Figure2. Change curve of natural disaster mitigation capability index of four streets with the equivalent amount of existing reserves.

By comparing the improvement of natural disaster mitigation capability of the four streets by the two methods, we found that the improvement of natural disaster mitigation capability of the four streets was the greatest when all the funds were invested in the equivalent amount of the existing reserves. On this basis, we analyzed each street separately and gradually increased the index to the limit value to analyze the impact of the index change on natural disaster mitigation capability of the four streets. As shown in Figure 2, the results show that when the index increases to 1.5 million yuan, the ranking of natural disaster mitigation capability of Longhua Street rises to the second place among the 13 streets, and the index of natural disaster mitigation capability basically does not change until it increases to 20 million yuan. For Tianlin Street and Xujiahui Street, when the index increases to 3 million yuan, the change of natural disaster mitigation capability index tends to be flat. When the index of Caohejing Street increases to 4 million yuan, the index of natural disaster mitigation capability basically remains unchanged.

5. Conclusion

We used TOPSIS to assess natural disaster mitigation capability of 13 streets in Xuhui District . By changing the weights, we explored the impact of weight changes on the results. Two methods were used to analyze the optimal way to improve the natural disaster mitigation capability of streets. The results show that the change of index weight has no significant effect on the natural disaster mitigation capability of each street in Xuhui District. The key index affecting the natural disaster mitigation capability of Xuhui District is the equivalent amount of the existing reserves. In the case of a certain amount of funds, putting all the funds into the equivalent amount of the existing reserves will improve the natural disaster mitigation capability of the streets most significantly. Meanwhile, when this index increases to a certain value, it has basically no effect on the improvement of natural disaster mitigation capability. This also provides a scientific reference for the government to make decisions.

6. Reference

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