Construction and Application of Comprehensive Risk Assessment Model for Disaster-bearing Bodies in Mega-city Based on Multiple Natural Disaster Scenarios

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Abstract

Shanghai is located in the coastal area of the Yangtze River Delta in eastern China, facing threats from various disasters such as typhoons, storm surges, flooding and ground subsidence. How to quickly find the dangerous disaster bearing bodies when the disaster comes becomes an important problem. Therefore, the objective of this study is to build a comprehensive risk assessment model of disaster-bearing bodies based on natural disaster scenario data and disaster-bearing bodies attribute data.

We constructed a comprehensive risk assessment indicator system according to three dimensions of hazard, vulnerability and exposure. The comprehensive risk assessment model of disaster bearing bodies was constructed by weighted calculation input indexes, and realized automatic comprehensive risk assessment of the disaster-bearing bodies in large-scale. The weights of input indexes are determined by summarizing historical disasters data and scored by experts. We use this model to evaluate the comprehensive risk level of the disaster-bearing bodies under multiple natural disaster scenarios, and analyze the distribution of risk levels. The regional disaster reduction risk (DRR) capacity of Shanghai and the comprehensive risk level of the disaster-bearing bodies were combined by disaster matrix to determine which high-risk disaster-bearing bodies are located in areas with low DRR capacity.

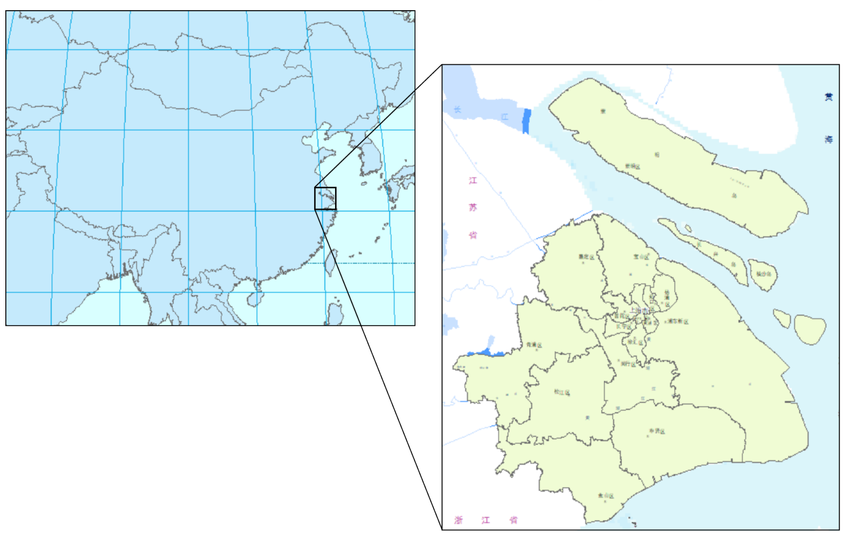
Key words: Multiple Natural Disaster Scenarios; Building Comprehensive Risk; Mega City; Comprehensive Risk Assessment

Introduction

As a mega-city with an area of 6,340 km^2 and a population of over 24.75 million, Shanghai is densely populated with disaster-bearing bodies such as buildings, which are easily affected by natural disasters. Frequent natural disasters will cause significant population and economic losses. This study builds a comprehensive risk assessment index system based on three dimensions of hazard, vulnerability and exposure, and extracts the indexes for calculation. In terms of risk, we chose six major disasters affecting Shanghai, including earthquake, land subsidence, typhoon, flood, forest fire and storm surge. Through weighted calculation and classification, the risk level of a single-block building is obtained. Finally, the comprehensive prevention level is obtained by the disaster matrix.

Objective

The research area of this study is Shanghai, China.



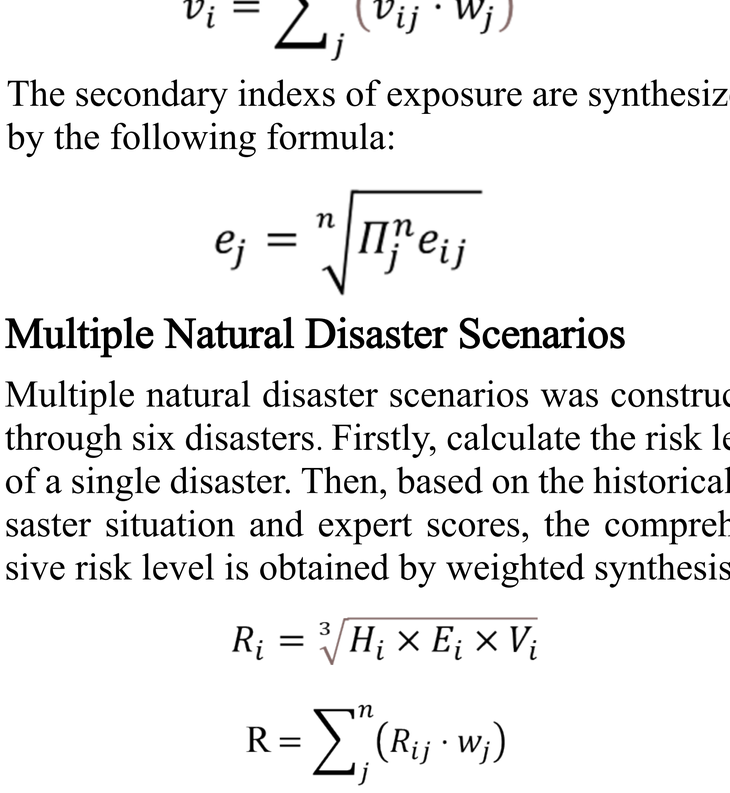
The research objectives are:

1. Explore the comprehensive method of multi-disaster hazard data on the scale of individual houses
2. Extract the vulnerability and exposure indexs of the disaster-bearing bodies based on the buildings' attribute information.
3. Construct the comprehensive risk assessment model of disaster-bearing bodies in mega-city

Methods

Vulnerability and Exposure

The selection of building vulnerability and exposure indicators is shown in the figure followed, and some indicators are corresponding to disaster types.



The secondary indexs of vulnerability are synthesized by the following formula:

$$v_i = \sum_j^n (v_{ij} \cdot w_j)$$

The secondary indexs of exposure are synthesized by the following formula:

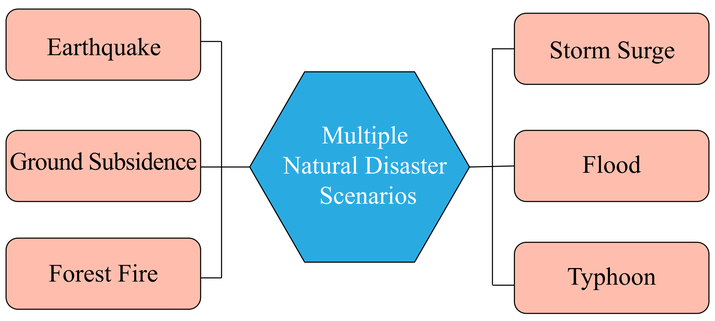
$$e_j = \sqrt[n]{\Pi_j^n e_{ij}}$$

Multiple Natural Disaster Scenarios

Multiple natural disaster scenarios was constructed through six disasters. Firstly, calculate the risk level of a single disaster. Then, based on the historical disaster situation and expert scores, the comprehensive risk level is obtained by weighted synthesis.

$$R_i = \sqrt[3]{H_i \times E_i \times V_i}$$

$$\mathrm{R} = \sum_j^n (R_{ij} \cdot w_j)$$



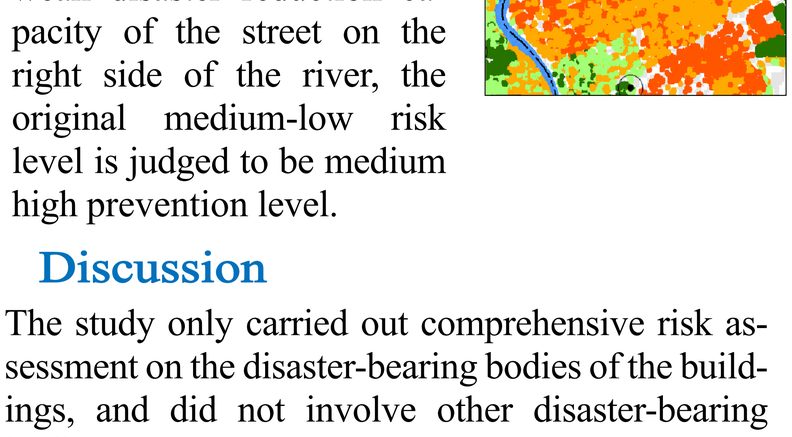
Disaster matrix

The comprehensive prevention level is used to judge the building with high risk level and low regional disaster reduction ability, which is calculated by the disaster matrix below.

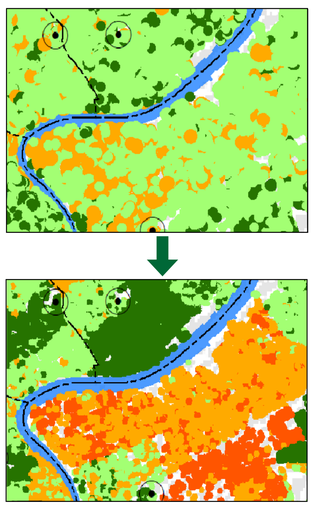
Comprehensive Prevention Level		Disaster Risk Reduction Capacity				
		Low	Medium Low	Medium	Medium High	High
Comprehensive Risk Level	High	High	High	Medium High	Medium High	Medium
	Medium High	High	Medium High	Medium High	Medium	Medium Low
	Medium	Medium High	Medium High	Medium	Medium Low	Low
	Medium Low	Medium High	Medium	Medium Low	Low	Low
	Low	Medium	Medium Low	Low	Low	Low

Results

Through the model, we get the comprehensive risk level information of buildings in Shanghai, including the risk, vulnerability, exposure and risk level of the single disaster. The following two radar maps show the specific disaster risk information for a particular building.



The right figure shows the impact of regional disaster reduction capacity. The top of the right figure is the results of the comprehensive risk assessment of buildings in one area, and the bottom is the results of the comprehensive prevention level. Due to the weak disaster reduction capacity of the street on the right side of the river, the original medium-low risk level is judged to be medium high prevention level.



Discussion

The study only carried out comprehensive risk assessment on the disaster-bearing bodies of the buildings, and did not involve other disaster-bearing bodies.

The disaster species considered in the study is limited, and other disaster species affecting disaster-bearing bodies in Shanghai can be added in the future.

Conclusions

The comprehensive risk levels of buildings in Shanghai are mostly medium low or low, and the buildings with a comprehensive risk level of medium are mainly distributed in the downtown area.

The comprehensive prevention level of one quarter of the streets is above medium high, so it is necessary to increase the investment of disaster protection in these streets.

Major References

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