基于多自然灾害情景的超大城市承灾体综合风险评估模型构建与应用

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上海市位于中国东部的长江三角洲沿海地区，面临台风、风暴潮、洪涝、地面沉降等多种自然灾害的威胁。同时，上海市作为一个面积 6340 平方千米，人口超过 2475.89 万人的超大城市，建筑物、道路、轨道交通等承灾体高度密集，频发的自然灾害将带来巨大的人口与经济损失。因此，本文将基于多灾种自然灾害危险性数据与承灾体属性数据，构建承灾体综合风险评估模型，评估不同情景下承灾体面临的自然灾害综合风险等级。通过分析承灾体综合风险等级的分布与变化特征，能够提前发现存在隐患的承灾体，减少灾害可能带来的损失。

首先，基于房屋建筑与道路承灾体单体的位置信息与属性信息，按危险性-脆弱性-暴露度三个维度构建了综合风险评估指标体系，并提取出用于计算的指标。同时我们模拟了房屋建筑、道路承灾体相关的地面沉降、台风、洪涝、风暴潮灾害危险性信息，其中地面沉降灾害通过小基线子集（Small Baseline Subset, SBAS）技术对 2017-2021 年 Sentinel-1A 数据进行反演得到。我们还基于不同的 SSP-RCP 情景，模拟了海平面上升、暴雨等气候变化下洪涝灾害的淹没范围与水深变化。通过对输入指标进行加权综合计算与结果分级，构建承灾体综合风险评估模型，实现了大规模的承灾体综合风险自动评估。输入指标的权重通过汇总历史灾情与专家打分的方式确定。在不同的灾害情景下，使用模型对承灾体的综合风险等级进行评估，分析风险等级的分布特征与变化情况。最后，使用灾害矩阵将上海市区域减灾能力数据与承灾体综合风险等级值综合，判断哪些高风险承灾体所处区域的减灾能力没有满足灾害管理需求。

关键词：多自然灾害情景，房屋综合风险，道路综合风险，灾害模拟

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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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. 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, roads, and metro, which are easily affected by natural disasters. Frequent natural disasters will cause significant population and economic losses. Therefore, the objective of this study is to build a disaster-bearing body Comprehensive risk assessment model based on natural disaster scenario data and disaster-bearing body attribute data. Through analyzing the distribution and change characteristics of the disaster-bearing bodies' comprehensive risk level, we can detect hazards in advance and reduce the potential impact of natural disasters.

Firstly, we constructed a comprehensive risk assessment indicator system according to three dimensions of hazard, vulnerability and exposure, based on the location and attribute information of buildings and roads, and extracted the calculation indexes. We also simulated hazard Scenarios related to buildings and roads, including ground subsidence, typhoons, floods, and storm surges. Ground subsidence information is retrieved with 2017-2021 Sentinel-1A data and Small Baseline Subset (SBAS) technology. On the other hand, we simulated the effects of sea level rise and rainstorm brought by climate change on the inundation range and depth of flood disasters in different SSP-RCP scenarios. 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 scoring by experts. We use this model to evaluate the comprehensive risk level of the disaster-bearing bodies under different disaster scenarios, and analyze the changes in the risk levels. Finally, 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.

Keywords: Multiple Natural Disaster Scenarios, Building Comprehensive Risk, Road Comprehensive Risk, Natural Disaster Simulation.