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An OWA Application on Urban Land Use Hazard Vulnerability Assessment

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Introduction

Under the threat of climate change, different types of land use will impact disaster vulnerability in various ways. This study focuses on the regions of Xinzhuang, Wugu, Luzhou, Sanchong, Taishan, Banqiao, and Shulin in the Xibei area of New Taipei City. It emphasizes the vulnerability of land use, resilience analysis of national land function zoning, and exploration of risk issues related to land use planning.

Since current land use reflects actual spatial development, it is suitable for physical environmental vulnerability analysis. Functional zone, with its planning characteristics and development control, is conducive to discussions on adaptation and resilience. These analyses of vulnerability, adaptation, and resilience can serve as the foundation for risk governance.

Initially, this study explores land use vulnerability, categorizing and evaluating the current state of land use, major structures, and disaster prevention and mitigation facilities within the study area. It lists evaluation indicators to analyze vulnerability factors. The "Land Use Vulnerability Index" in this study mainly consider the current state of land use, environmental development usage, and related physical facilities for disaster prevention and mitigation. The purpose is to evaluate land use vulnerability. After evaluating the land use vulnerability indicators, an OWA analysis is conducted. This involves overlaying the spatial assessments of the three land use aspects with different risk weights for a comprehensive vulnerability analysis.

Land Use Vulnerability Index

Referencing the discussions, classifications, and evaluations of land use vulnerability by Burton et al. (1993), Li, Wang, and Song (2022), and Botezan, Radovici, and Ajtai (2022), this questionnaire's framework for land use vulnerability indicators primarily considers the current state of land use, urban structures, and emergency facilities as the three main evaluation categories. These categories are composed of 22 indicators, as shown in Figure 1.

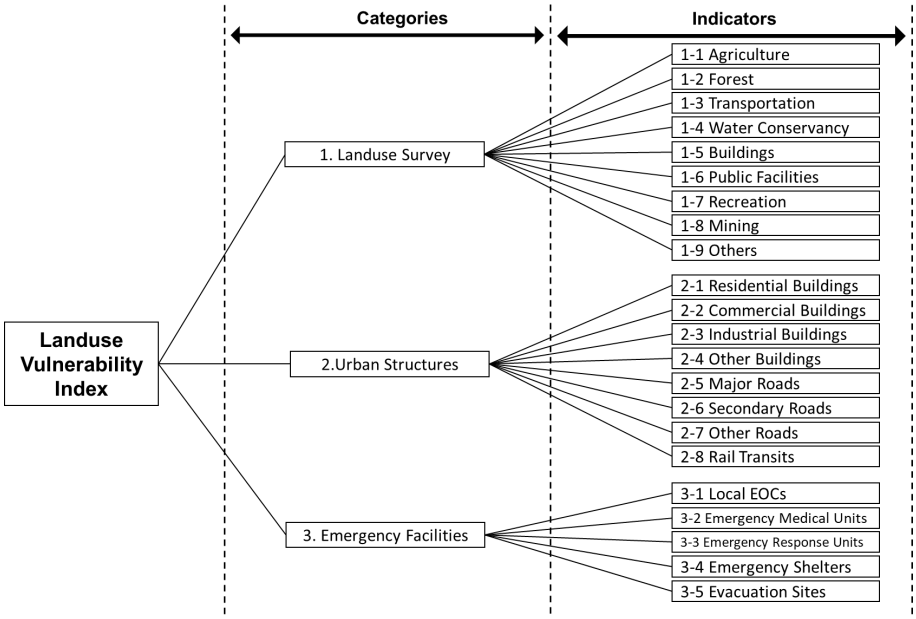

Figure 1. Land Use Vulnerability Index.

The 22 indicators in Figure 1 are broadly divided into three categories: land use survey, urban structure, and emergency facilities. These categories are comprised of 9, 8, and 3 indicators, respectively.

OWA Land Use Hazard Vulnerability Analysis

OWA (Ordered Weighted Averaging), proposed by Yager in 1988, addresses the significant task of integrating various criteria to form an overall decision across many academic fields (Yager, 1988). The relationships among these criteria structures are crucial in the integration process. Researchers aim to satisfy all criteria while ensuring that each satisfied criterion meets their expectations. These two aspects are achieved through the 'and' and 'or' operators (also known as 'ANDness' and 'ORness'), which combine the criteria functions and are the purpose behind developing the ordered weighted averaging method.

For example, in evaluating the land use disaster vulnerability indicators in this study, assume a grid lacks disaster prevention and mitigation facilities but contains buildings. If evaluated solely based on the weighted criteria, the vulnerability of the buildings in the grid would be reduced due to the consideration of disaster prevention and mitigation facilities. By applying the OWA method through the concept of risk trend, when the value of ANDness increases (tradeoff approaching 0), it highlights the high vulnerability factors within a single area. Conversely, as the tradeoff value approaches 1, the influence of the criteria weights on the various vulnerability factors becomes more apparent. This study evaluates the distribution of disaster vulnerability under different conditions by overlaying layers with various OWA combinations and different sequential weight values and arrangements.

Six OWA combinations are proposed with different risk scenarios as fig. 2 for land use vulnerability:

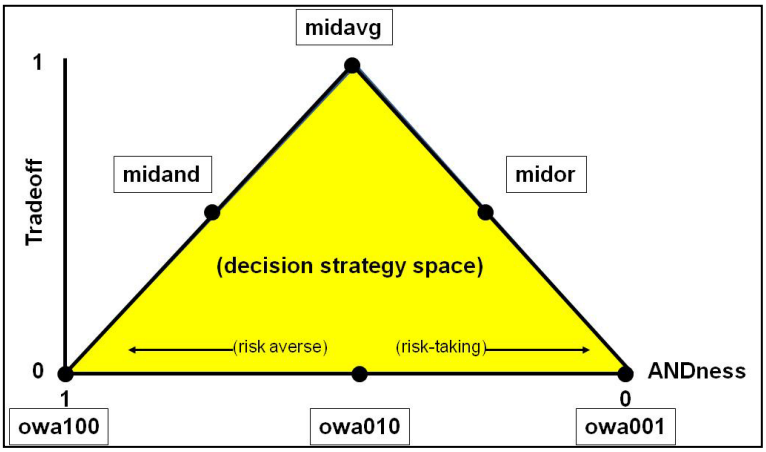

Figure 2. OWA Scenarios for Land Use Vulnerability.

The analysis results of six land use vulnerability scenarios with flood hazard are illustrated as Figure 3:

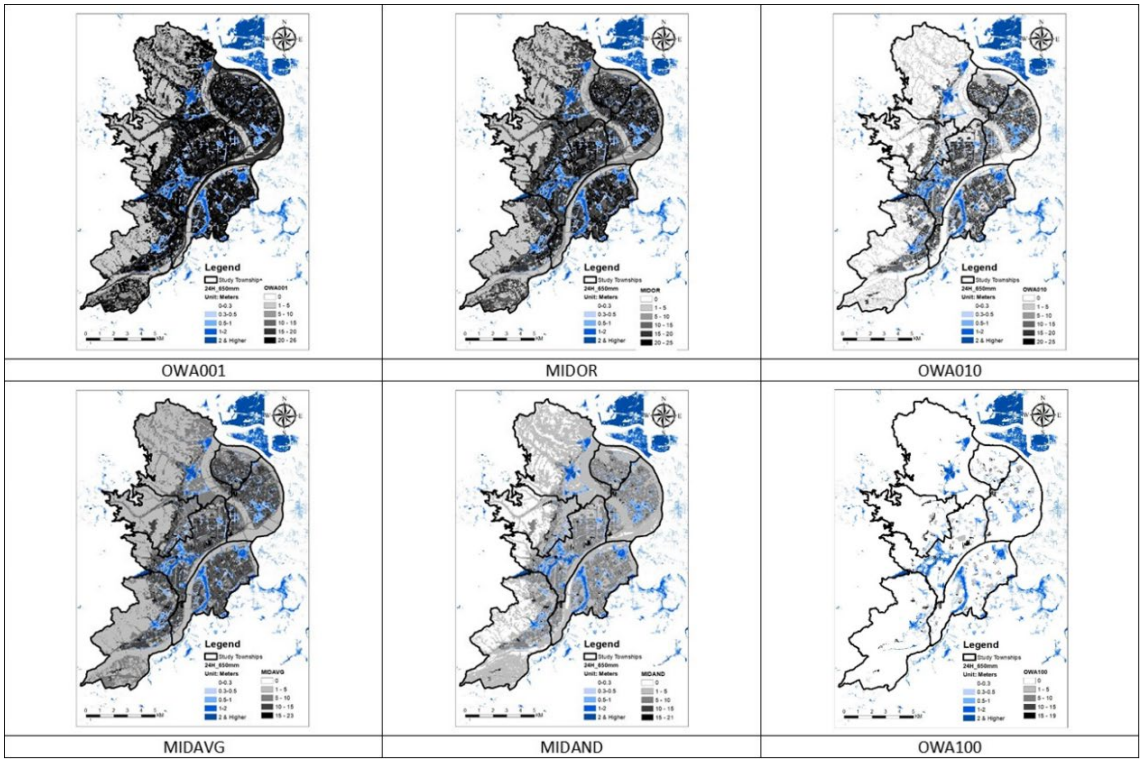

Figure 3. Land Use Hazard Vulnerability of OWA Analysis.

In addition to flood hazard, spatial locations of other different hazards, such as fault, landslide, debris flow, soil liquefaction, large-scale landslide, are overlaid with the OWA analysis results for further discussions.

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