Assessment and Uncertainty Urban Vulnerability Caused by Earthquake Using FAHP Model (Case Study: Sanandaj)

Peyman Yariyan a, Mohammadreza Karami b *

a MA in Geography Information System Department of Geography Information System (GIS), Mamagha Branch, Islamic Azad University, East Azerbaijan, Iran
b Assistant Professor in Geography and Urban Planning, Department of Social Sciences, Payame Noor University, Tehran, Iran

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1. Introduction
The population of cities is on the rise and is constantly exposed to a variety of human and environmental hazards (Alexander, 1993). Earthquake is one of the most important disasters affecting cities and urban land use. Natural disasters such as earthquakes have been a serious and permanent threat to humans and human settlements, which have endangered human life in areas with high seismicity. That is why it was named as the deadliest natural disaster in the world in 2001. Iran is also one of the most earthquake-prone countries in the world, which has always witnessed high casualties in its cities due to this disaster (WDI, 2004). Meanwhile, the occurrence of any earthquake in urban such as Sanandaj in Kurdistan Province has negative and irreversible effects on the whole region. Therefore, the assessment of urban vulnerability caused by earthquake, despite Morvarid Faults, Sartakht, etc. in Zagros Mountains is necessary. The purpose of this study is to assess the vulnerability of Sanandaj City due to earthquake with an emphasis on uncertainty approach using FAHP model. In addition, a comparison is made between the AHP and FAHP models.

2. Materials and Methods
In this study, three environmental, physical and social factors with 13 criteria were selected. The selection of criteria has been based on previous studies, and it has been attempted to select the variables that have the most relevance and impact. Layer maps were obtained in the form of raster and vector data from formal offices. After editing and correcting for possible errors, all layers in ArcGIS software were converted to raster format. The layers were then standardized. According to the studies, the weight of each layer (AHP model weights 1-9) and their fuzzy thresholds were then determined. Finally, the final result in five vulnerability classes (i.e. very low, low, medium, high and very high) were identified. The maximum-minimum method was used to standardize the layers. After standardization in ArcGIS 10.4 software, pairwise comparisons matrix was formed through the AHP method. By introducing initial weights, final weights and AHP map was obtained. In order to implement the FAHP
model, after identifying the type of membership function and increasing or decreasing the amount of each layer, the fuzzy method was used in IDRISI software environment. Then, in ArcGIS software using Raster calculator tool, each of the fuzzy layers was multiplied and aggregated in the final weight of the AHP model. First, each fuzzy layer was multiplied individually in its own weight using the Raster calculator tool. Then, the new maps were executed by five fuzzy operators (SUM, GAMMA, OR, AND, PRODUCT) and the final map was prepared based on SUM operator as the best operator, which is most consistent with the current situation in Sanandaj.

3. Results and Discussion

Based on the results of both AHP and FAHP models, most areas with high physical vulnerability have undesirable characteristics such as poor quality of materials, burnout and high density land use. From social perspectives, they also have high population density, which corresponds to worn-out textures and marginalized neighborhoods. However, comparing the two AHP and FAHP models shows the higher accuracy of the FAHP model. In general, the FAHP model is highly capable of formulating the uncertainties of the present study.

4. Conclusion

While the AHP method uses quantitative and qualitative variables, it is not capable of modeling uncertainty about decisions makers. One of the capabilities of the Fuzzy-AHP model in this study is to utilize different spectra through normalization methods based on minimization and maximization. This method eliminates the uncertainty in the ranking of actions and decisions in the AHP method. Accordingly, zones 1, 2, and 3, respectively, are most vulnerable to earthquake, which are consistent with the worn-out texture and margin of the city. The district 1 of Sanandaj, districts such as Ghatarchian, Tazeh abad, Haji Abad, Besat and district 2 in Abbas Abad, Golshan, Pir Mohammad and finally district 3 in Mubarak Abad, Kalaka Jar, Vila shahr and Baharan Town are highly vulnerable. In general, zones 1, 2, and 3, respectively, are the most zones vulnerable, which are highly adapted to the worn-out texture and margin of the city. Therefore, the most important proposal of this study is comprehensive planning and construction operations in the suburbs and worn-out areas, which should be regarded as a priority to deal with possible earthquakes.

Keywords: Uncertainty, Earthquake Risk Assessment, Fuzzy-AHP, Modeling, Sanandaj City

References (In Persian)


References (In English)


