Multi-Hazards Risk Analysis of Damage in Urban Residential Areas (Case study: earthquakeandflood hazards in Tehran- Iran)

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1. Introduction

Probabilistic risk analysis is a systematic approach capable of bringing multiple expertizes and fields of sciences together for a comprehensive analysis of performance of engineering systems. Moreover, risk analysis is a managerial tool in hands of the disaster managers for decision making considering different methods to examine reactions to probable risks and vulnerabilities. At international policies level, the term "multi-hazards risk analysis" was first introduced in UN permanent development plan (UNEP) in 1992. The document calls for "complete multi-hazard research" as a part of man settlement programming and management in hazards prone regions (UNEP 1992).

The term multi-hazards risk analysis was used again in Johannesburg program for "integrated protecting and managing the natural resource base of economic and social development" (UN, 2002).

Then, the Hyogo Framework of Action (UN-ISDR 2005) adopted this aspect and suggests an "integrated, multi-hazard approach for disaster risk reduction into policies, planning and programming related to sustainable development, relief, rehabilitation, and recovery activities in post-disaster and post-conflict situations in disaster- prone countries." (UN-ISDR,2005).

Moreover, the term multi-hazards was used in the strategy plan for reducing national disaster in the USA (FEMA, 1995), devised to attenuate risk of national disasters effects and concentration on multi-hazards on design and structure of buildings.

Multi-hazards analysis as defined by Delmonaco et al. (2006) is "implementation of methodologies and approaches aimed at assessing and mapping the potential occurrence of different types of natural hazards in a given area".

Multi-hazard risk survey and evaluation was subject of a study by Xing et al. (2008). After dealing with probabilities, they obtained risk of hazard (assets and infrastructures) quantitatively.

Javanbarg and his colleagues surveyed analysis of multi-hazards in binary networks. In their analyses, they considered the infrastructure components as nodes and links, and failure and simultaneous effects of multi-hazards considered as failures on links and nodes were assessed.

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Finally they obtained failure risk of a binary network. (Javanbarget al.2009).
Schemidt et al. (2012) proposed a framework for multi risk modeling (earthquake, volcano, flood, wind, and tsunami) and developed RiskScape software designed to calculate multi-hazard risks. The software was written in JAVA with some limitations.
Considering necessity of accurate information of regions and districts for preventing and managing and urban programming, it is essential to conduct studies for controlling and identifying hazards and threats in Tehran. To this end, we need to survey and study different districts, maneuverability of the city and analyze vulnerabilities. Cleary, the results are helpful in strengthening crisis management system before the event.

2. Study Area

District No. 20 (Shahr-e-Ray) is located in far south of Tehran city with an area of 23km^2, inside the main body of the city and circled in an area of 153km^2. Traces of life in the district reach back to 6000 years and the region is home to many historical elements and religious centers including Abdolazim's tomb; these centers make the region distinguishable among the other regions. Old neighborhoods are one of the outstanding features of the region. Shahr-e-Ray is one of the oldest cities of Iran. The district is threatened by Ray Fault and other faults under Tehran city and positioned in Sorkh-e-Hesar downstream. Taking into account hazards such as flood of 2001 and the historical earthquake of Shahr-e-Ray, it is vital to conduct surveys and studies aimed to reduce vulnerability and manage the hazards.

3. Material and Methods

As pictured in Figure 1, the method of the study includes flood and earthquake hazard analysis modules, flood and earthquake damages analysis modules, and multi-hazard risks analysis module. What follows is a brief introduction to each module.

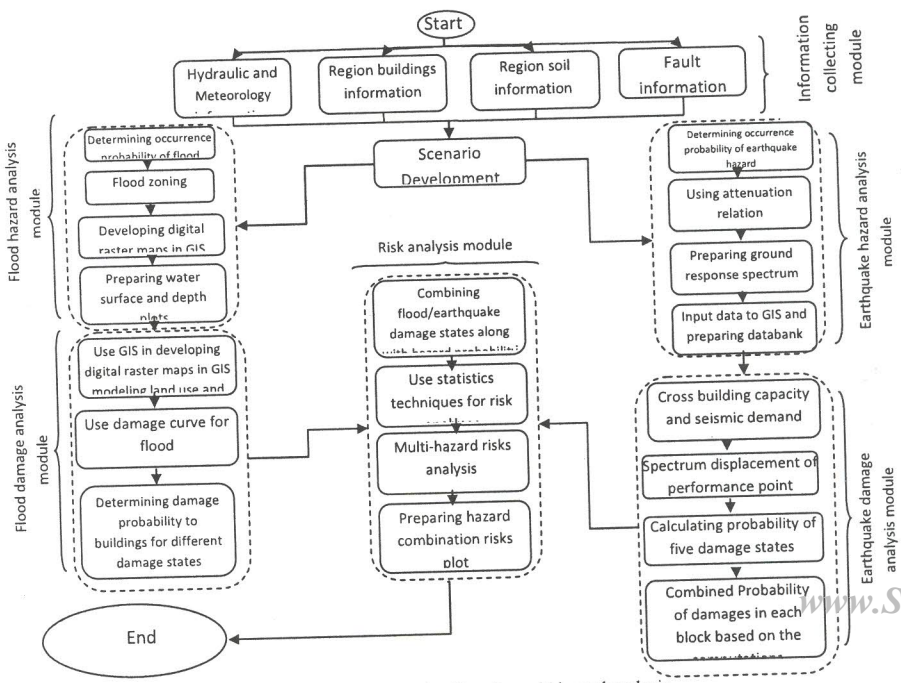

Figure 1: Propose algorithm for multi hazard analysis

4. Result and Discussion

Different scenarios based on the status of hazards occurrence status and their consequences are explained in follow table. A 7 magnitude earthquake and a flood with return period of 100 years are considered.

Considering the scenarios of this table and using the explained methodology the damage probability for residential buildings of the region is calculated. Then the multi-hazars risk of damage is analyzed based on the probability of scenarios, the probability of damage states and the number of structures in each block. The resultant risk of "flood and not earthquake", "earthquake and not flood", and "earthquake and flood" were calculated for different damage states. Inputting the results in GIS, Mutli-Hazards risk maps were generated. The results for scenarios 2 and 10 are pictured in figures 11 and 12.

Different scenarios

Scenario	Earthquake	Flood	Common cause Event	Damage state
1	Yes	No	CCE2	Slight (DS1)
2	Yes	No	CCE2	Moderate (DS2)
3	Yes	No	CCE2	Extensive (DS3)
4	Yes	No	CCE2	Complete (DS4)
5	No	Yes	CCE3	Slight (DS1)
6	No	Yes	CCE3	Moderate (DS2)
7	No	Yes	CCE3	Severe (DS3)
8	No	Yes	CCE3	Collapse (DS4)
9	Yes	Yes	CCE4	Slight (DS1)
10	Yes	Yes	CCE4	Moderate (DS2)
11	Yes	Yes	CCE4	Extensive (DS3)
12	Yes	Yes	CCE4	Complete (DS4)

5. Conclusion

A methodology and an algorithm for quantitative analyzing of Multi-hazard risk of damage of residential buildings were introduced and used. The method may be used alone for assessing risk of assets regarding a single hazard. However, it is a comprehensive analysis procedure that takes multi-hazards into account (consecutive hazards in particular) and assets risks resulting in more realistic quantitative results. There are cases where some of the hazards are missed in urban planning and programming or it is not easy to calculate the result of implement preventive measures against some of the hazards. The proposed method introduces a framework to address this challenge. Multi-hazard risks maps answer this issue as they deal with all hazards in one place and depict the effects and dependencies of the possible hazards. Such maps can be dealt as bases for risk management and integrated disaster management. Although, in case of multi-hazard analysis the risk is reduced up to 15% and 2% with respect to earthquake single hazard or flood single hazard, respectively (because simultaneous incident of flood and earthquake is very rare (0.39 * 0.22)), damages in the case of multi-hazards are shifted to the extensive and heavy states for all structures and 33 percent increase in number of complete damages is expected. Moreover, based on multi-hazards at complete damage state, the number of damaged masonry, steel, and concrete structures increases in a fold of 1.25, 1.26, and 1.5, respectively.

Key Words: Multi-hazards, Risk analysis, earthquake, flood, Tehran- Iran.