Evaluation of the urban vulnerability against earthquake in Dastgheib district of zone 9th of Tehran

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Abstract: Iran is located on the Alpine orogeny belt; hence it is one of frequently earthquake-occurring areas of the world. In this research, due to importance of the risk of earthquake in Iran and specially Tehran, the Dastgheib district from area-9th of Tehran is selected to introduce the vulnerable parts of the city. Since the Dasgheib district has a high density of population and constructions, the identification of its earthquake vulnerability is of essential concern. According to the summary of six main criteria of the urban planning factors studied by GIS software, it is shown that this area is one of the most vulnerable parts of the city. Therefore to avoid the damages of a possible earthquake, it is necessary to undertake studies and make certain arrangements as fast as possible before any unfortunate event. There are a lot of areas in Tehran similar to the district under study in this research and most of the results can be extended to them.

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1- Introduction

There have been always various dangers threatening humankind.

Nowadays mankind has achieved considerable knowledge about crisis management. In these kinds of studies the conditions of before, during and after a critical situation are taken into interest.

One of these critical conditions is the earthquake and its consequences which arises the necessity and importance of crisis management studies, specifically the evaluation of urban vulnerability against earthquakes. The purpose of this research is to evaluate the earthquake vulnerability in of densely populated districts of Tehran.

Since in Dastgheib district there are no previous studies in this regard, and it is one of the most populated areas of the city, we have taken it under study as a sample district.

Two methods, library study and field study are used to perform this. Additionally, to achieve final results, some important tools such as various plans are processed by GIS software. The research procedure can be summarized as follows: First, some library studies are done. Then field studies such as visual observations, interviews and questionnaires are fulfilled and finally, the local plans are plotted and arranged using GIS software.

Each plan is based on one of important criteria of urban planning.

Using all criteria and based on the proposed model, it is shown that this district is a reasonable template study for other densely populated areas of Tehran.

2- Background

Today the earthquake is no longer considered as a curse and it is faced as a natural and environmental fact.

By using effective precautions in developed countries such as United States and Japan, people are mostly adjusted to the earthquake conditions and its lethal and financial damages are greatly reduced.

In Japan, after the 1994 earthquake, some serious arrangements about persistency of buildings, construction of high-safety subways, individual home-trainings, job-making plans, etc. have been made (Zaghari 1382). In Italy, the 1980 earthquake motivated the government to completely reconsider their precautionary policies and reconstruction programs and the most completed urban vulnerability evaluation method was derived and used (Skeria 1996).

In Colombia since 1980s, due to serious damages of earthquakes, it has been decided to develop a model to estimate the earthquake risks using a

comprehensive approach based on the multi-criteria hierarchical AHP model.

To finally determine the relative connections between hierarchies, the Delphi method is used (Fathi 1385).

In Iran several schemes, regulations and projects, such as the regulation no. 2800 for buildings and the local seismic division of Tehran-e-Bozorg area.

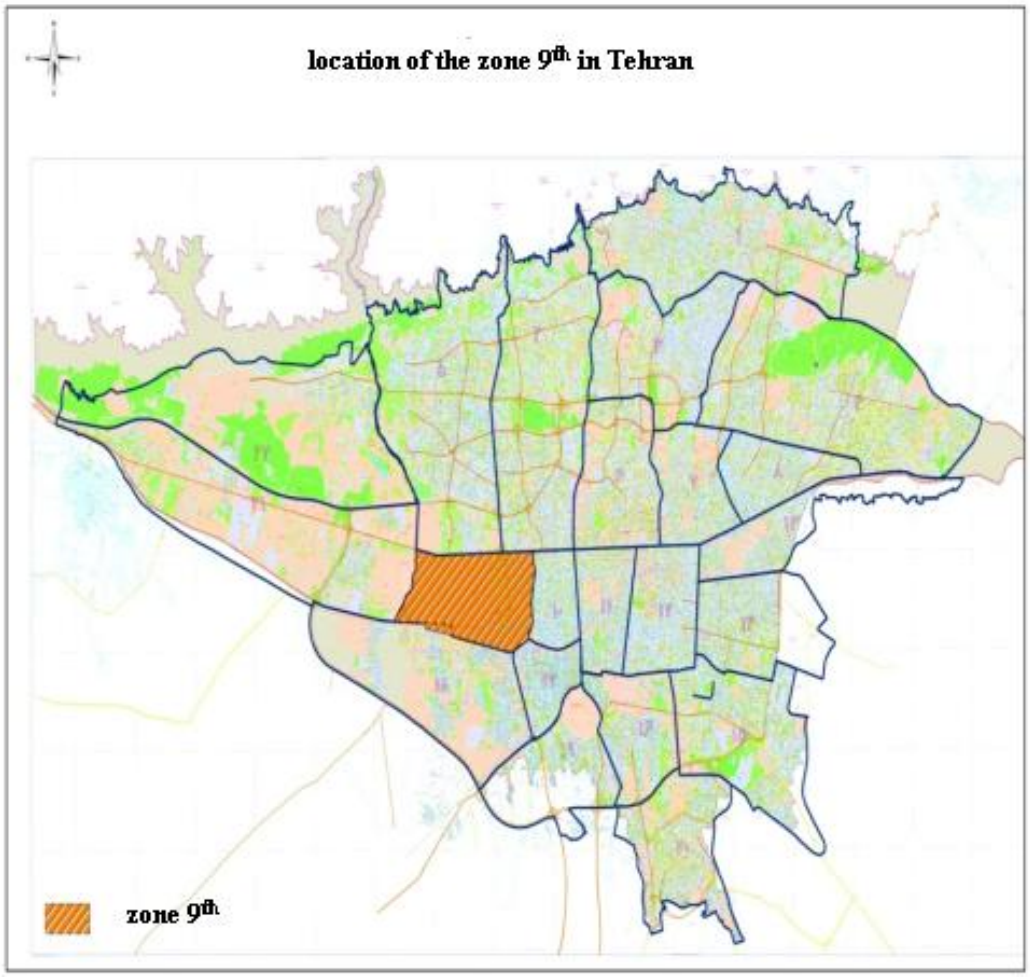
This project was accomplished on 1380 by joint efforts of "the center of seismic and environmental studies of Tehran" and "international cooperation agency of Japan".

Some students have carried out their dissertations in this field, such as "analyzing the role of urbanization on crisis management using GIS" (Khanverdi 1386), "evaluation of the urban vulnerability against earthquake, emphasizing the strategic factors and variables of zone 12th of Tehran" (Qotbi 1387), etc.

3- Location and extent

In this research the Dastgheib district, which is the district 3rd of zone 9th of Tehran, is taken under study. This district is located between longitude 52 56' 33" to 53 21' 21"E and latitude 49 38' 83" to 49 39' 47"N.

Map 1- location of the zone 9th in Tehran



Map 2- Location of Dastgheib district in zone 9th of Tehran

It is bounded from north by Hashemi Street, Ostad Moein district and Dr. Hooshyar district, from south by Nahre-Firoozabad street and Emamzade-Abdollah district, from east by Shahidan street and zone 10th of Tehran, from west by Saeedi highway and Mehrabad airport.

4- Geographical and anthropological features

It is located on an alluvial fan which has a smooth slope between 5 to 10 degrees and is over a formation. From geological point of view, it contains homogeneous conglomerates of sand and small grey or brown stones. In this area there is no fracture but it is under the effect of the north fracture and Ray's north fracture.

Total population of Dastgheib district is about 25400 whom are scattered on about a 60-acre area. There is approximately 2700 residential buildings in this district whose areas are mostly small and are built on low-width passages.

The district has a shortage of green areas and public open areas.

5- The proposed model

The model introduced here is a combination of some selected criteria, which tends to the study of vulnerability value in the selected area.

There are 6 criteria in this model and their mathematical representation is as follows:

$$\text{vulnerability} = f(k_1, k_2, \dots, k_6)$$

For each criterion a number is assigned due to the consult with experts, and the average value is considered as vulnerability.

Thus based on the present data we will have:

$$37.1 < K_t < 148.4 \qquad (K_t = \text{vulnerability})$$

5.1. Criteria and their effects

As pointed before, there are six criteria for evaluation of vulnerability against earthquake, which are as follows:

5.1.1 Open public areas

Open public area refers to parks, public sport grounds and arid unpopulated lands which are potentially capable of sheltering and evacuation of people and also, habitation of injured people during earthquake. The more these areas are, the less vulnerability will cause.

Table 1- Relation between open public areas and vulnerability

K_1	Vulnerability value	Radial distance (meters)
1	Low vulnerability	<=50
2	Medium -	50-150
3	High -	150-300
4	Very high -	Over 150

(Qadiri 98,1380)

5.1.2 Passage network

The passages have vital role in saving and help operations after earthquake. An efficient transport network is the one with higher width and higher ground relative to other urban constructions. Also it has few bridges and is directly connected to the passages outside the city to provide roadway access to damaged areas.

Table 2- Relation between passages width and vulnerability

K_2	Vulnerability value	Passages width
1	Low -	Over 14 meters
2	Medium	Between 9-14 meters
3	High	Between 3-9 meters
4	Very high	Less than 6 meters and dead-ends

(Fakhim 106,1385)

5.1.3 Total building area

Increasing the ratio of constructed areas to total ground area or open area, leads to the increase of open areas vulnerability caused by buildings collapse. Separation of lands in small areas causes the minimization of open areas and greatly reduces their effectiveness for sheltering during catastrophe.

Thus the vaster residential lands, the less vulnerability will be.

Table 3- Relation between residential vastness and vulnerability

K_3	Vulnerability value	Area (square meters)
1	Low -	$S \geq 300$
2	Medium	$200 < S < 300$
3	High	$100 \leq S < 200$
4	Very high	$S \leq 100$

(Qadiri 103,1380)

5.1.4 Buildings' age

The average value of building's effective age in Iran is approximately 30 years. The more building's age, the higher its vulnerability will be.

Table 4- Relation between building's age and vulnerability

K_4	Vulnerability value	Building's age
1	Low -	1-10 years
2	Medium	10-25 years
3	High	25-50 years
4	Very high	Over 50 years

(Hataminejad 6,1386)

5.1.5 Construction type

There are several construction type classifications in this field.

The construction type is a very effective factor in vulnerability against earthquake. The weaker building's construction is, the higher its vulnerability will be.

Table 5- Relation between construction type and vulnerability

K_5	Vulnerability value	Construction type
1	Low -	Iron frame
2	Medium	Bricks and iron
3	High	Wood and brick
4	Very high	Tent, mat and similar material

5.1.6 Population density

The population density is a factor that shows the relation between total area of the ground and its resident population (Taqavi 59,1387). It is possible that two spans with similar area have several densities.

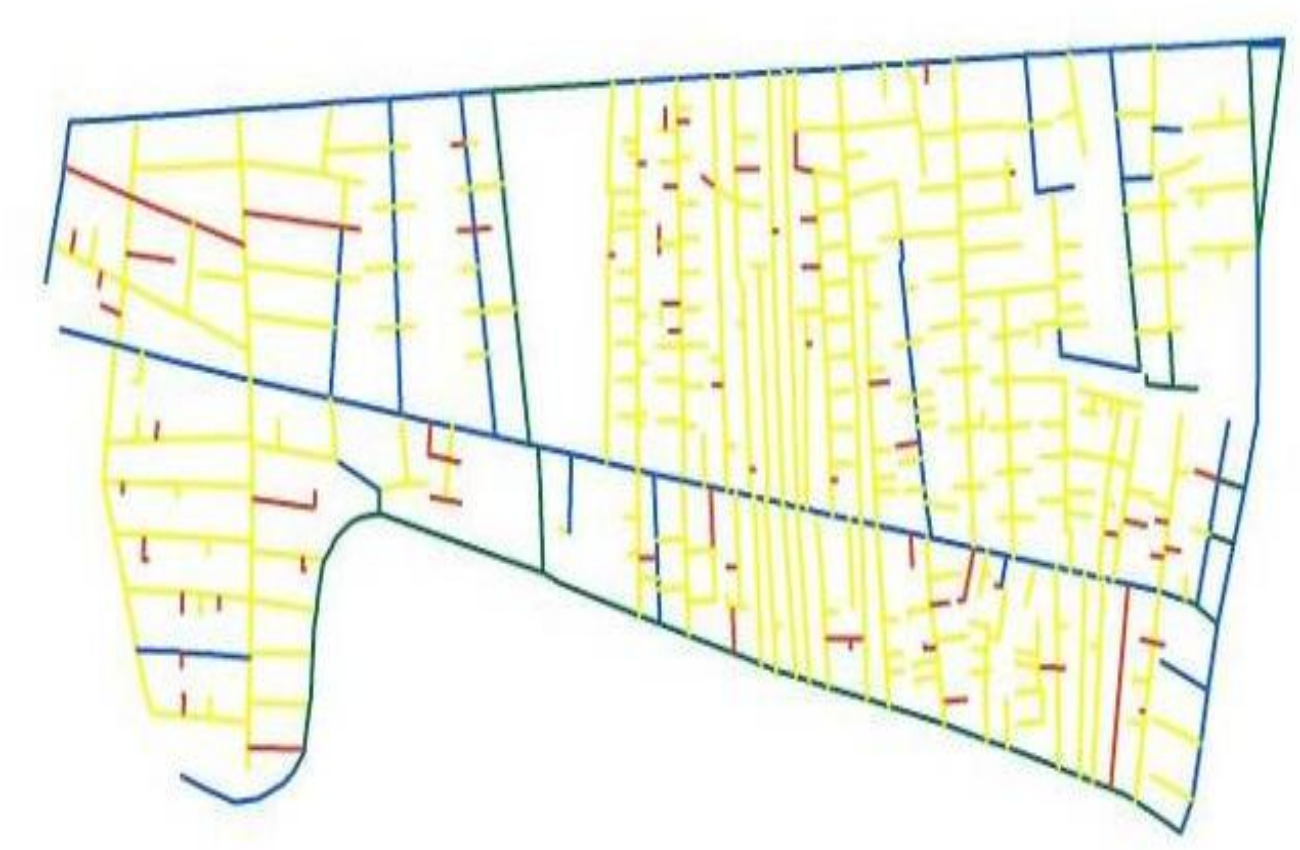
Table 5- Relation between population density and vulnerability

K_6	Vulnerability value	Population density
1	Low -	Less than, or equal to 400 person per acres
2	Medium	400-500 per acres
3	High	500-600 per acres
4	Very high	Over 600 person per acres

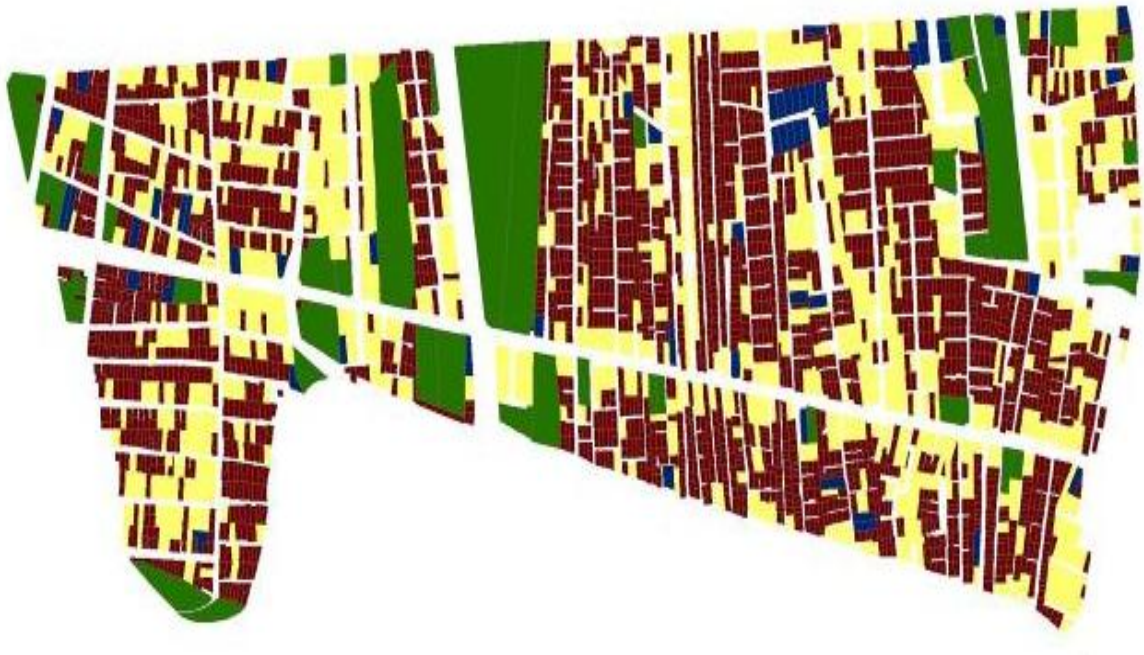
(Fakhim 104, 1385)

Based on these criteria and the proposed model, the results in Dastgheib district are as follows:

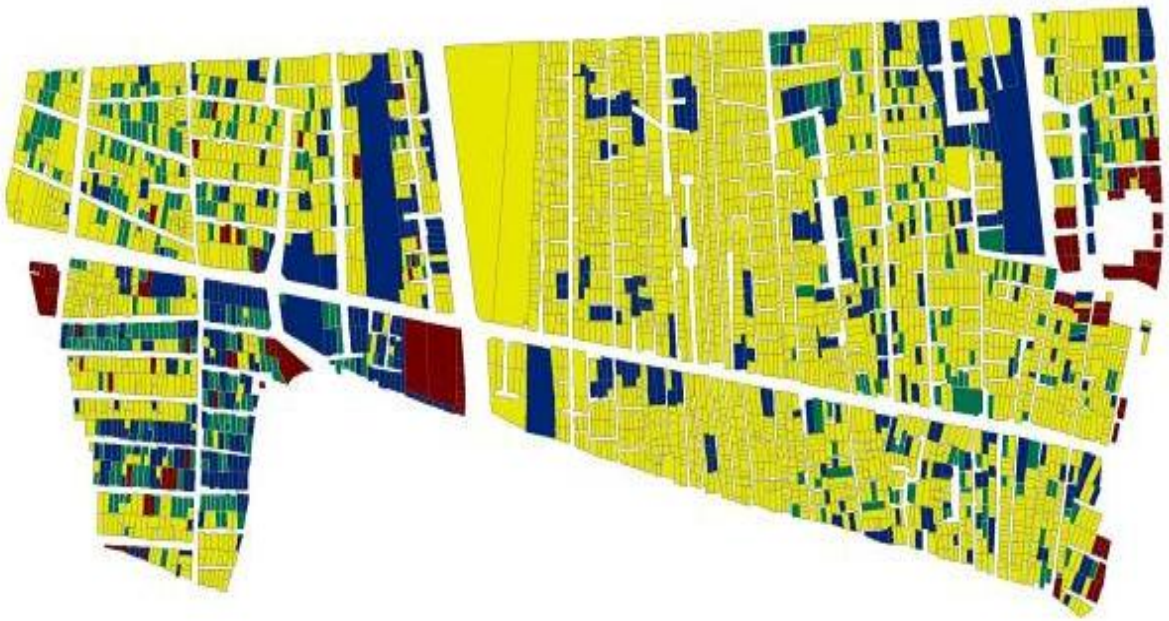
Map 3- Vulnerability caused by access to open public areas



Map 4- Vulnerability caused by public transport system and passages



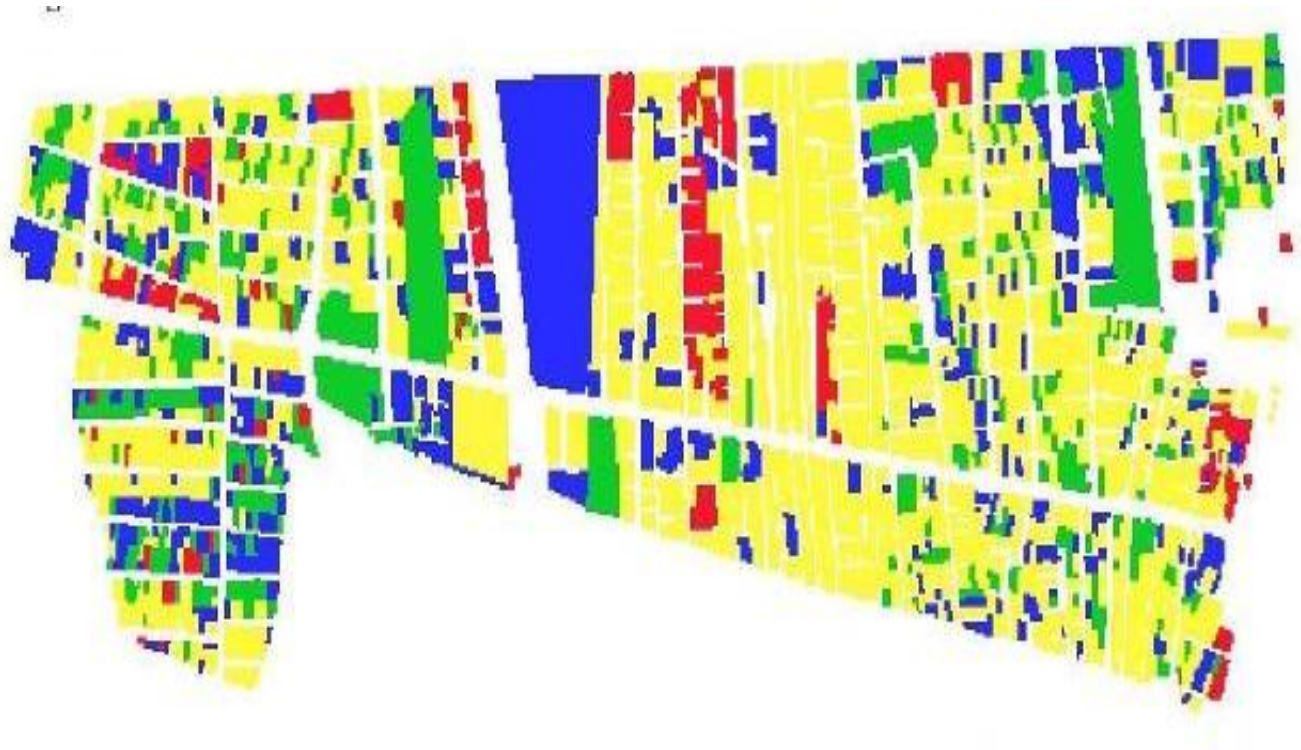
Map 5- Vulnerability caused by piecewise lands



Map 6- Vulnerability caused by building's age

Map 7- Vulnerability caused by construction type

Map 8- Vulnerability caused by population density



Map 9- Vulnerability caused by sum of all factors

Table 7- Urban vulnerability value against earthquake due to all effective factors in district 3rd (Dastgheib)

Very high vulnerability	High vulnerability	Medium vulnerability	Low vulnerability	Vulnerability value / Criterion
4/26	65/23	19/38	10/68	access to open public areas
16/51	69/07	9/77	4/65	access to public transport system and passages
47/92	31/22	3/55	17/2	Building's total area
5	65	19	10	Building's age
-	-	90	10	Construction type
1/99	1/18	6/28	90/55	Population density
7	54/8	20/9	17/3	All effective factors

According to the above table and GIS maps of Dastgheib district in zone 9th of Tehran, this district has high vulnerability in about all criteria.
Therefore this district must be concerned in urban planning for elimination of its shortages.

6- Conclusion

In this research a district vulnerability has been evaluated which has a lot of similar areas in Tehran. This may be help urban planners to solve some of problems before a catastrophe like Bam earthquake. The selected criteria have covered construction problems and also urban planning shortages.
The resulted maps are slightly different from other researches in this field, and this research procedure can be a template way to evaluate other urban districts.
According to the resulted maps, the district 3rd has a high vulnerability which can be very dangerous at earthquakes of 7 Richter or more.
Thus it is essential to reconsider some plans to minimize possible damages.

7- Suggestions

Due to high vulnerability of the studied district, these suggestions can reduce the possible damages:

1- Renovation and refurbishment of old urban texture of district 3rd according to the construction standards.

2- Accumulation and high-level aggregation of population in order to use the space more effectively.

3- Hierarchical organization of city streets and open spaces

4- Proper distribution of open spaces and building and population densities

5- Preparing rescue tools to access the safe areas

6- Public education to face a disaster risk

7- Encouraging people to participate in facilitating rescue

8- Adopt the necessary measures for insuring the buildings against earthquakes

9- Create a secure area for quick and easy relief

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