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Modeling for Seismic Vulnerability Prediction Based on Physical-Spatial Indicators of Cities (Case Study: Tabriz Region 8)

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Abstract

Nowadays, given the growing trend of population and population density in urban areas especially in densely populated cities and in terms of seismicity, the need for a comprehensive and inclusive approach to natural and catastrophic events resulting from their occurrence has become more apparent. The detrimental effects of over-population concentration in specific urban areas along with a lack of preventive planning and the lack of preparedness to deal with events such as earthquakes is a very serious and important threat to citizens and the continuation of urban life. In this study, District 8 of Tabriz was selected as a case study. The research method is descriptive-analytical and the purpose of this study is to evaluate and model for predicting seismic vulnerability based on physical-spatial indices of Tabriz considering the quality criteria and providing a suitable model and Pattern for construction in Tabriz. For this purpose, out of 9 criteria, building density, population density, quality of buildings (accessibility), access to pedestrian networks, access to essentials, access to open and green spaces, land use, size of fragments, and distance. Dangerous centers have been used and Necessary statistical data is collected, then layers are prepared for seismic zoning and layering is done according to zoning standards, the final analysis was performed using the combination of AHP and Fuzzy TOPSIS methods in GIS (proposed method). Finally, the risk level of the study area was obtained from Tabriz city. The results show that the northern areas have the highest risk areas and the southern areas have the least rate, and finally it is concluded that the proposed model for risk zoning is applicable.

Keywords: zoning, earthquake, Tabriz, fuzzy logic, multi-criteria decision making.

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1. Introduction

Natural disasters are one of the major problems in most cities around the world that cause critical conditions. One of the most important natural disasters causing the crisis is earthquakes. The earthquake zones are stretched along the Alps to the Himalayas. (Kirpes, 1998) that Iran is part of the Alpine-Himalayan-Caucasian orogenic belt known as the world's last and the youngest orogenic zones. The location of cities on high-risk areas greatly damages the lives and property caused by the earthquake. The geological structure of the Iranian plateau and its margins are related to the folded belt system of the Tertiary, which is a potential and positive factor in terms of mineral reserves and economy and a negative factor in seismic evolution (Ramazani Gorabi, 1372). Our country is in the middle of the Himalayan Alpine orogenic belt (Fall Suleiman et al., 2013). Southwestern Arabia and India from east and southwest and Siberia from the northeast press on Iran and Iran's resistance to pressures has led to numerous faults and fractures, and the activity of these faults has made Iran one of the most important earthquake-prone areas in the world. The energy generated by the pressures stored in fault zones and after being released as destructive waves of earthquakes causes the demolition and destruction of cities, which is mostly due to the activity of these faults (Zomorodian, 2002). During the 20th century, more than 1,100 destructive earthquakes occurred in various parts of the world, resulting in the loss of more than 1,500,000, 90% of which was mainly due to the collapse of buildings that did not have sufficient safety. (Lantada,2008) prominent example of this is Japan, where several earthquakes occur each year with more than seven earthquakes in various parts of the country. Due to proper urban infrastructure does not cause disruption and disruption in urban systems. (Yamazaki, 2005).

The present study aims to assess the vulnerability of the city to earthquakes with emphasis on physical indicators in the historical context of Tabriz. Given that Tabriz is located near the high-risk fault and especially Tabriz historical context with different antiquities, it is necessary to identify areas that are vulnerable and plan for improvement of conditions. Given the importance of assessing the vulnerability of cities to earthquakes in geography and urban planning, this paper attempts to use fuzzy logic by combining the process of hierarchical analysis (AHP) and FTOPSIS on GIS environment. The risk of earthquakes in cities should be provided using spatial and descriptive data of the main components and elements of construction behavior and determining the effect of each of the criteria used on the degree of damage. Physical dimensions can be considered as the most tangible and important role of urban planning in reducing the effects of an earthquake. The shape and physical structure of the city include various elements that are organized through urban planning and design (Hatami Nejad et al., 2014). This section can be divided into physical divisions of the city and neighborhood system, communication and hierarchical network system, urban centers, vacant levels, sections and localities, urban signs, segmentation and blocking system, different urban texture patterns, urban open spaces, demographic and construction, land use distribution and finally the direction of city development and expansion (Asadi Nazari, 2004).

1.1. Theoretical buildings achieve

Readiness in the face of events is largely a function of the location of the settlement and its natural geography, as well as the physical characteristics of the settlements.If we consider crisis management in a broader sense than post-accident operations, it involves reducing risks, providing permanent preparedness, and meeting specific post-accident needs, both emergency and short-term or long-term, and thus broader communication with Finds urban planning and urban design (Ahmadi, 1374). Disaster planning is recognized as one of the types of urban planning and is a comprehensive process for disaster preparedness and response, which is implemented at both the pre-disaster and post-disaster stages. Pre-disaster planning is a set of actions that either avert disaster or reduce the impact of the disaster and prepare the community for responding to disaster impacts (Aguilar et al., 2009). Pre-disaster planning is divided into three phases: disaster prevention planning, disaster mitigation planning, and disaster preparedness planning. Post-disaster planning is a process of identifying the necessary post-disaster measures to make the most of available resources and facilities. The three phases of this type of planning include rescue and emergency relief planning, planning the period of planning, and planning the reconstruction (Farrokhnia, 2004).

1.2. Concept and definitions of vulnerability

"Vulnerability" is a measure of the degree of damage caused by the stimulus. This has been extensively discussed in the natural and social sciences with regard to factors such as hazards, climate change, health, epidemiology, crime, military planning, ecology, and engineering. (Ahadnejad, 2009) To better understand the concept of vulnerability, it is necessary to analyze the factors and processes that determine the effect of the driver on the system in terms of the damage to it.

- The concept of vulnerability implies measuring the risks associated with economic and social levels in order to be able to overcome the consequences of an accident (Smith, 1996).
- Vulnerability refers to the inability of people to face the risks that are based on the position of individuals and groups in the physical and social world (Clark et al., 1998).
- Vulnerability is a certain degree of damage in an area that is defined as an aftermath of earthquakes and other natural hazards, often referred to as zero (non-vulnerability) and one (complete vulnerability) (Chen et al., 2001).
- Vulnerability is the potential for any kind of harm, whether natural, spiritual , or immaterial, by an agent. (Little et al., 2000).
- From this point of view, the pattern of earthquake effects and their destruction is not accidental and has a particular dependence on the characteristics of urban areas. Therefore, vulnerability patterns refer to natural hazards and factors such as social order, spatial organization, urban location, and the relationship of society to the environment.

Vulnerability Components from an Urban Planning Perspective:

Identifying the risk factors and consequently estimating the degree of damages is a very important step in urban planning. If this is the case, it is possible to minimize the devastating effects of an earthquake by making the necessary predictions and using control tools. Therefore, the vulnerability components will be identified first and then the appropriate defense method adopted (Figure 1).

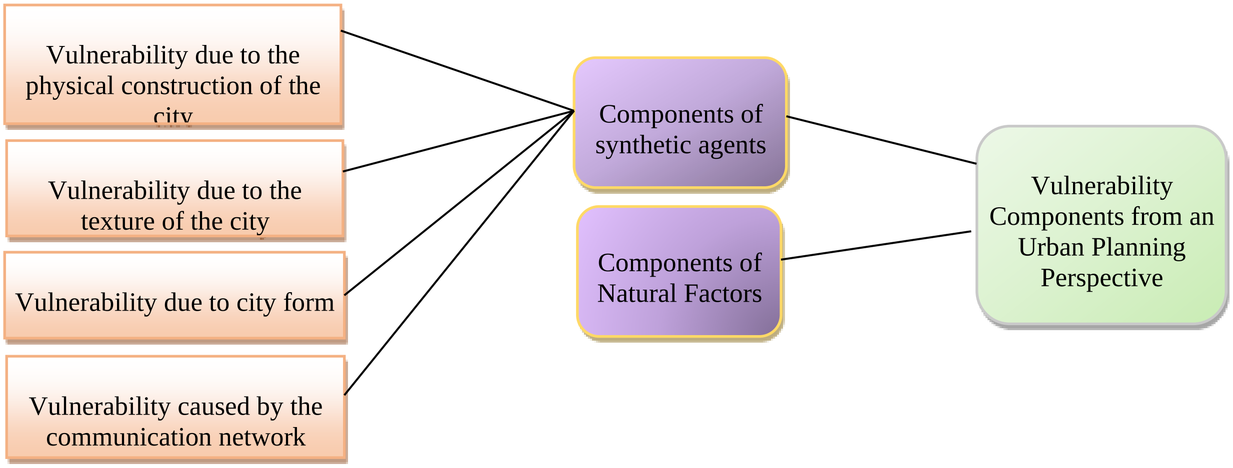

Figure1. Diagram of vulnerability components from the perspective of urban planning

As the chart above shows, the body, texture, and form of the city are the most important artifacts that are directly related to the vulnerability of the city. City form is considered as the most important criterion in earthquake risk analysis (Bahraini, 1994).

1.3. Vulnerability of old and worn tissues

The most vulnerable areas of the earthquake are in the context of worn-out textures. The definition of worn-out texture from an earthquake hazard perspective differs from the definition of worn-out texture from an earthquake hazard perspective with conventional definitions of urbanization. Factors such as the presence of old buildings, narrow and narrow passages, lack of open spaces, lack of access to rescue, rescue and treatment facilities, and the presence of hazardous facilities are indicators that are important in classifying degraded tissues from the perspective of earthquake disaster management.

Old and worn textures have three main indicators:

Micronutrient: Blocks with more than 50% area less than 200 square meters.

Instability: blocks with more than 50% of the buildings being unstable and without structural system.

Impermeability: Blocks with more than 50% passages less than 6 meters wide.

The vulnerability of worn-out (old) tissues to urban elements

Worn-out texture is often found in cities with a more historical background. In this context, there is no pre-thought thinking, and the road network is often based on pedestrian movement and topography of the area. The grid is partially connected to the surrounding area. Another characteristic of the texture is the spatial deprivation and deadlock of the passages. In many cases, the commute is high and the streets are deadlocked. Rider traffic is also hierarchical and traffic on the inner roads is reduced. In worn-out texture, irregular shapes of land fragments cause more irregularities in building forms. (Bahreini, 1373).

The vulnerability of old tissues to passages and road networks

Road networks are considered to be an important factor in the formation of components that have not been molded in an organic and worn-out, molded and regular manner. Due to the same feature of the crosswalk at many intersections, there will be no standard conditions. Although the road network is not the only, cause of the damage, features such as narrow alleys, the curved path and the closure of roads, increase the likelihood of damage and casualties from accidents such as earthquakes, in other words, the destruction of networks, mainly Road and building. The pattern of buildings' incorporation into parts and roads can lead to an increase in the degree of congestion and blockages caused by the collapse of adjacent buildings, in which case the pattern of access can, with increased access, reduce the loss of tissue efficiency due to its internal artery occlusion (the same). Source: 104). Spatial deprivation and closure of alleyways in worn-out textures will not be suitable for this purpose. In addition, in the winding and bending passages of organic and worn-out fabric, the ability to elude and seek refuge is significantly reduced (Lagayi, 2004)

2. Material and Methods

2.1. Study Area

District 8 of Tabriz comprises the central core of the city with an area of about 386 hectares, with a population of 34231, representing a gross population density of 89 people per hectare. Figure 2 is the location map of the study area for the 2014 Landsat satellite. Figure 3 is the position map of the study area, shown in green. Tabriz's most important historical and ancient monuments, such as Tabriz Bazaar, Kaboud Mosque, Tabriz Jame Mosque, Tabriz Citadel, Tabriz Municipality Palace, and so on. Tabriz's old neighborhoods such as Rastegocheh, Chaharmahar, Sanjaran, Myarmar, Dochchi, Sarakh, IchriArmenistan, as well as all the historic gates of Tabriz, including Damirqapi, Baghmisheh Door, "Red Door", "Dochchi Door", "Istanbul Door", "Gajil Door", "Qalaqapusi", "Nubar Door" and "Street Door" have been built in the area. but due to natural disasters, only the street door remains intact and the rest of the doors have been completely destroyed and no traces of them are left today. Also, the rich neighborhoods of Tabriz, where the nobles and elders of the city lived and have, are located in this area. These neighborhoods include Imam Friday, Cui Islamie, Cui Angj, Haram Khan, and Cui Ein al-Dawlah, Cui Kurbasi, Kolkatai Cui, Mojtahed Cui, Majid al-Molkai Cui, Jami Masjid Cui, Cui Mirmiar Cui, and Armenia Cui.

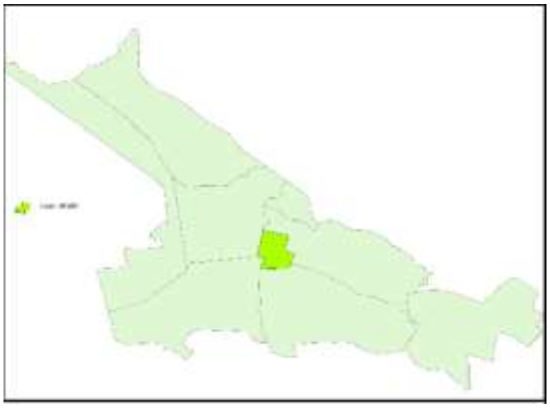

Figure 2. Location map of the study area for Landsat Satellite 2014

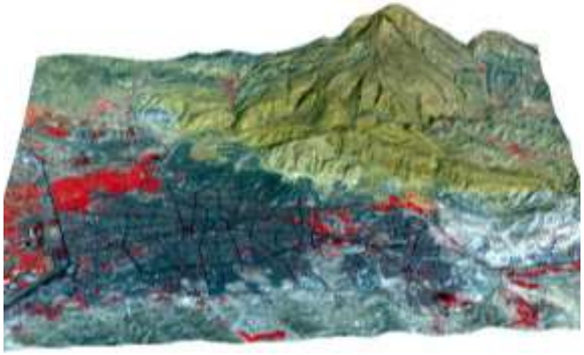

Figure 3. Location map of the study area

2.2. Research method

The present study can be considered as a part of analytical-exploratory research in terms of nature and research method. Due to the nature of the data and the inability to control the behavior of the variables affecting the problem, the research is non-empirical and the first step is to collect data. Documentary and library form and examination of various texts on the subject of an earthquake and its damages, the study area of this study is Tabriz city. At first, the necessary criteria have been selected using past studies and expert opinions. Then, by using hierarchical analysis of criteria weights according to expert theories have been obtained. The triangular numbers of the weight of the criteria are fuzzy, followed by the optimization of the positive and negative data using TOPSIS model and finally the final mapping in GIS environment.

Step 1: After the final weight of the criteria is obtained through AHP, the qualitative components (high utility, high utility, etc.) are then converted to quantitative components using fuzzy numbers so that the data are out of state. Become subjective in the objective that is, in the numbers based on the triangular fuzzy method we multiply those numbers by the scores obtained in the AHP method to obtain the fuzzy weight.

Step Two: In Table 11, the fuzzy numbers are multiplied by the AHP numbers and finally the FAHP matrix is obtained and the scores are specified. At this point, we are going to add the positive and negative ideals to the matrix, and for this purpose we have considered the largest numbers of lines to be the positive ideal and the smallest numbers to be the negative ideal, so that by subtracting the ideal value from Determine each element and obtain the distance from the positive and negative ideal, and finally divide the three vertices into each column d̃ _ij ^ + and d̃ _ij ^ -.

2.3. Method of data analysis:

The most important part of the GIS is the data processing and analysis of the data and the result of the GIS. Analysis is an operation performed on data and information to obtain the necessary capabilities with the help of mathematical knowledge. Data analysis was performed in GIS using multi-criteria decision-making models.

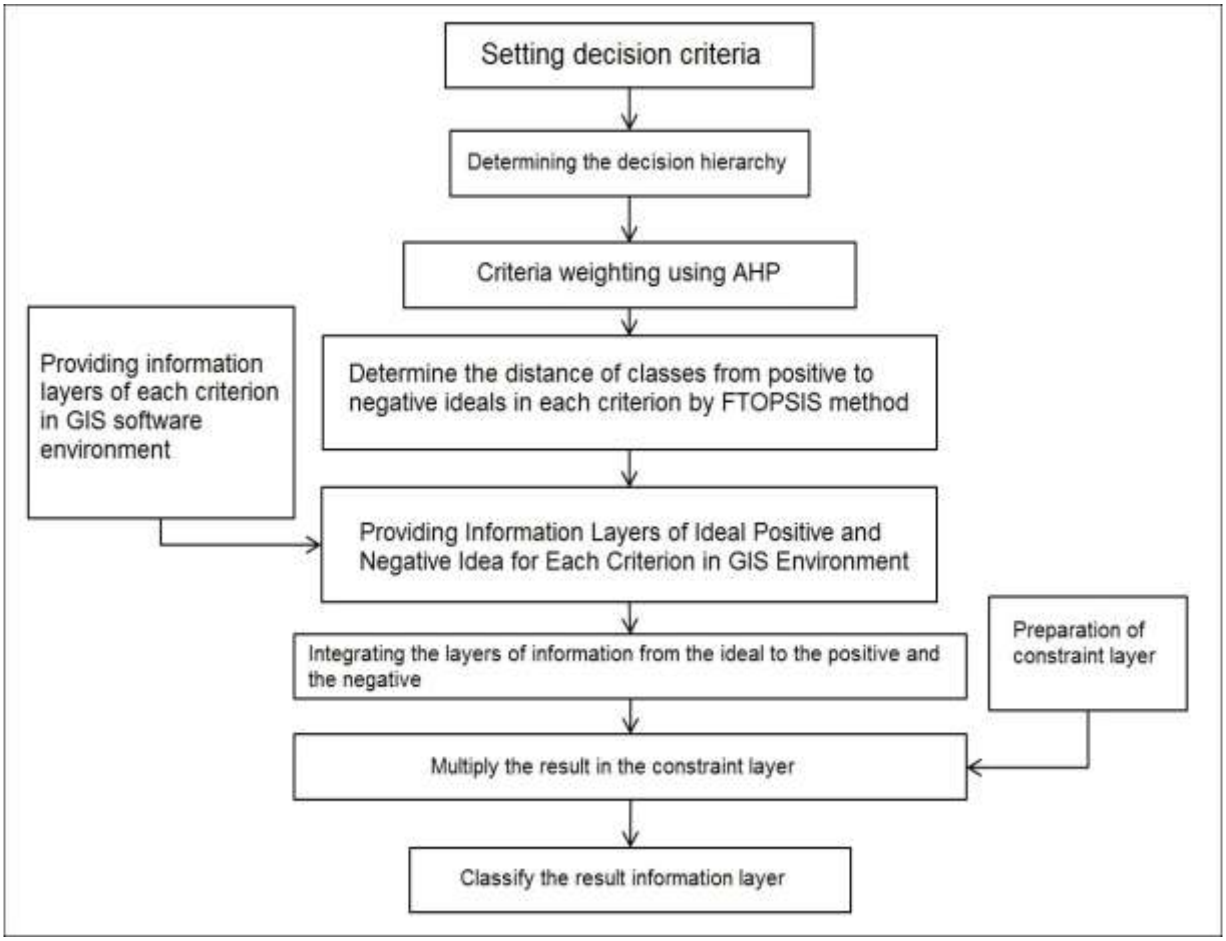

Figure 4. Method used in this study

3. Results and Discussion

3.1. Investigating the Condition of Building Congestion in Different Areas of The City

According to the results of the analysis carried out in Tabriz region 8, the density is divided into 4 zones from very low to high density. The study of the distribution of zones in zone 8 shows that homogeneity of construction is not distributed. Table 1 shows the density distribution zones and Figure 5 shows the abundance of zones in zone 8.

What results from the analysis of the building density index is that the vulnerability is very low and only about 7% of the area is highly vulnerable. Of course, in this area due to the market of Tabriz city and the traditional texture of the city has low building density.

Table 1. The amount of each of the vulnerability classes based on the building density index

Percentage	Area (m^2)	floors
63.53	10315	Low vulnerability
13.09	2126	Moderate vulnerability
15.43	2505	High vulnerability
7.95	1290	Very high vulnerability

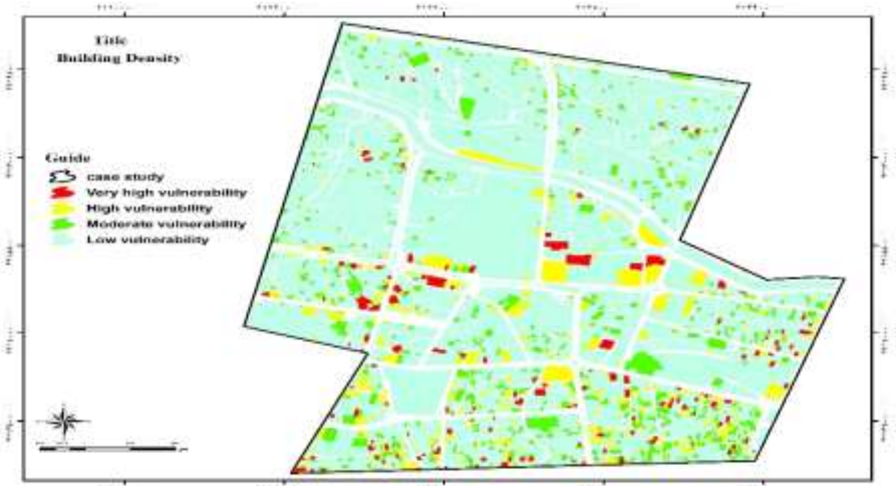

Figure 5. Overview of building congestion in different areas of the city

The study of population density of Tabriz Region 8 is in good condition with respect to the dominant performance in commercial performance of this index. Approximately 50% of the total area is classified as less vulnerable and approximately 25% of the total area is classified as more vulnerable.

Table 2. Percentage of Vulnerability Classes Based on Population Density Index

Percentage	Area (m 2)	floors
12.16	997028	Low vulnerability
37.62	1514979	Moderate vulnerability
24.76	614595	High vulnerability
25.45	410278	Very high vulnerability

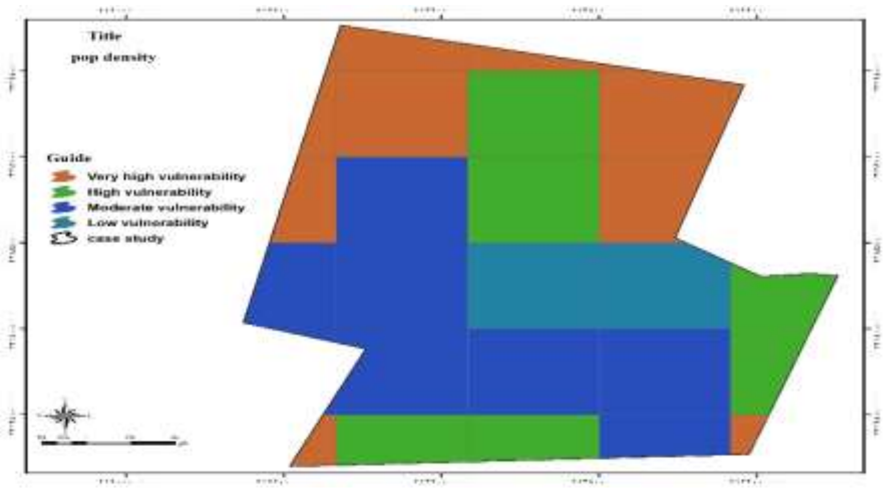

Figure 6. Population Density Vulnerability Classes

3.2. Land Use

There is no definitive ruling regarding the vulnerability of any type of earthquake. In this field should be "how the land uses, the types of densities (demographic, structural and residential), the mentioned densities, the land segmentation with different uses order and size of parts, the amount of compaction and connectivity, the physical characteristics of structures. The constituents and etc. are examined and studied. (Rough Hand, 2005.) Due to the variety of users in the study area, have been classified the users according to the vulnerability. The results of the map show that 48% of the vulnerability group is very high as the study area has the most use. Residential and commercial buildings that cause congestion, and on the other hand, the quality of passageways and materials used in the buildings a score of 48%.

Table 3. The extent of each of the vulnerability classes by user index

Percentage	Area (m 2)	floors
16.24	508664	Low vulnerability
9.33	292394	Moderate vulnerability
25.72	805649	High vulnerability
48.71	1255933	Very high vulnerability

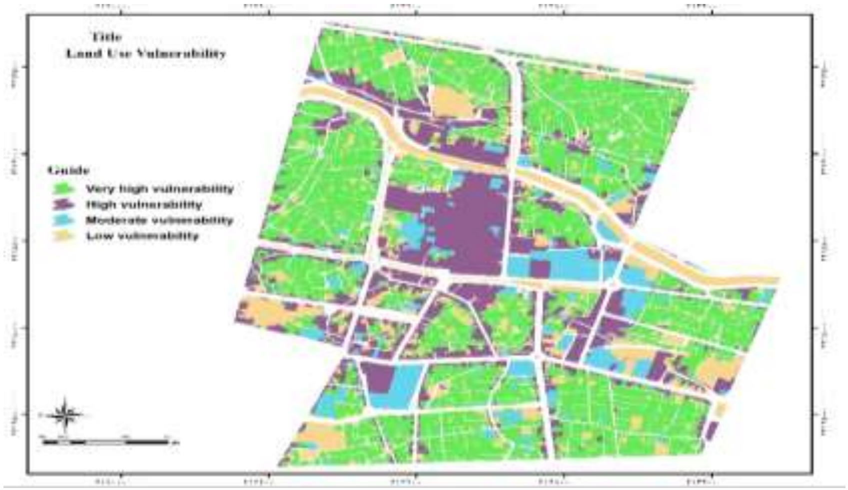

Figure 7. Land Use Index Vulnerability Classes

3.3. Average Residential Size (Micro)

The average index of residential size, which in the minimal case is referred to as tissue micro-knowledge, is one of the main factors affecting the seismic vulnerability of urban tissues. The importance of this index is to such an extent that the High Council of Architecture and Urban Development has identified it as one of the three major branches of urban tissue burnout. The results show that almost half of the texture of the area is within the vulnerable range. Region 8, due to the fact that it is one of the traditional textures of Tabriz, most of them have parts lower than 200 meters. What is noteworthy is that the Tabriz market, which is located in Region 8, is a fragmentation of the fine texture due to its being covered and subdivided into smaller units and can be subdivided into vulnerable areas.

Table 4. Degree of vulnerability index for each of the classes

Percentage	Area (m 2)	floors
19.90	341379	Very low vulnerability
15.97	500297	Low vulnerability
15.83	495886	Relatively vulnerable
10.49	328719	High vulnerability
46.81	1466355	Very high vulnerability

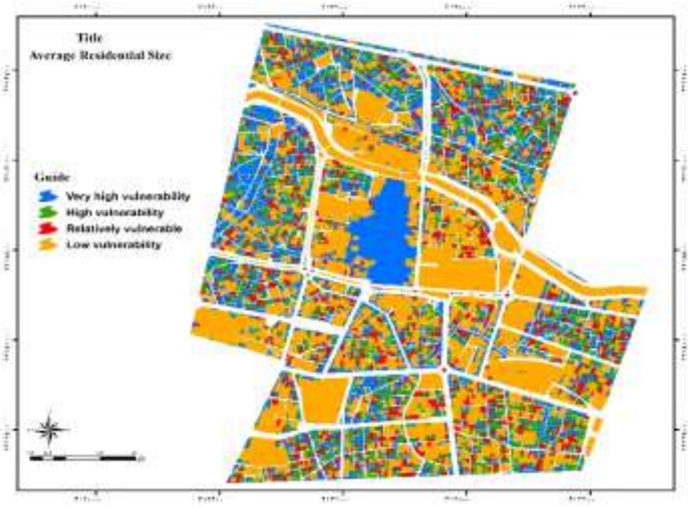

Figure 8. Vulnerability Index Vulnerability Classes

3.4. Vulnerability Due to Building Quality

Texture quality in buildings can be evaluated as a complementary index along with the index of age in urban tissue vulnerability. In fact, the quality of buildings in an urban context is a product of the quality of buildings in terms of technology and materials. In order to evaluate the quality index of buildings, it is necessary to collect information about the construction system of all buildings according to the results of the quality map of the buildings and showed that about 7.11% demolished, 53.07% maintainable, 25.46% refurbished, and 14.35% are newcomers and overall, only 14 percent of building quality is acceptable, doubling the need for crisis planning.

Table 5. Percentage of Vulnerability Classes by Building Materials Index

Percentage	Area (m 2)	floors
7.11	189696.1	Destructive
53.07	1415021	Maintainable
25.46	678919.6	Restoration
14.35	382585.9	Newcomer

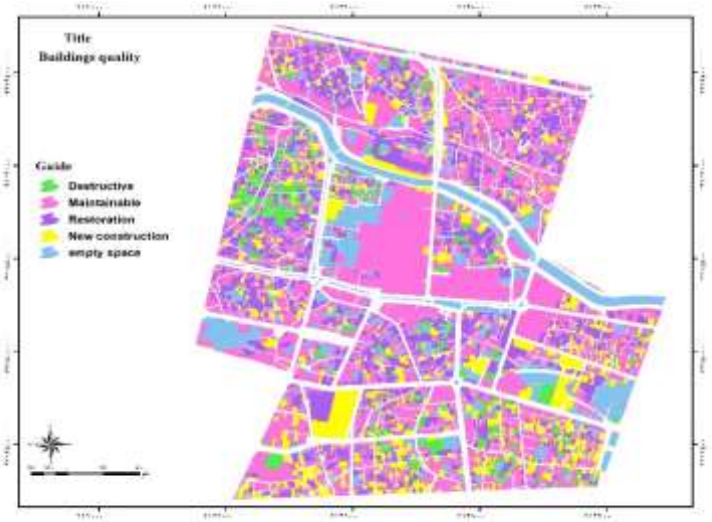

Figure 9. Vulnerability classes of building materials index

3.5. Investigating and Identifying Important and Vital City Centers and Sensitive and Hazardous Land Uses

There are points in any crisis that are known to be sensitive and dangerous, although they do not pose a threat in their own normal circumstances, by their characteristics, each of them has exacerbated the crisis and may have caused damage. And to increase casualties by several times. In critical conditions caused by an earthquake, these hazardous areas can cause an explosion, fire, and flood and can cause the effects of the crisis and its casualties. These centers include refueling stations (gas and gas), gas pressure reduction stations, substations, municipal water tanks, etc. The results show that there is a high relative risk range for this index in Tabriz Region 8. As such, 26.22% of the vulnerabilities are very high, 39% are highly vulnerable, which should be taken into consideration when locating these sensitive centers.

Table 6. percentage of Vulnerability Classes Based on based on the index of open space access

Percentage	Area (m 2)	floors
9.46	380852	Low vulnerability
24.41	982969	Moderate vulnerability
39.91	1607018	High vulnerability
26.22	1055871	Very high vulnerability

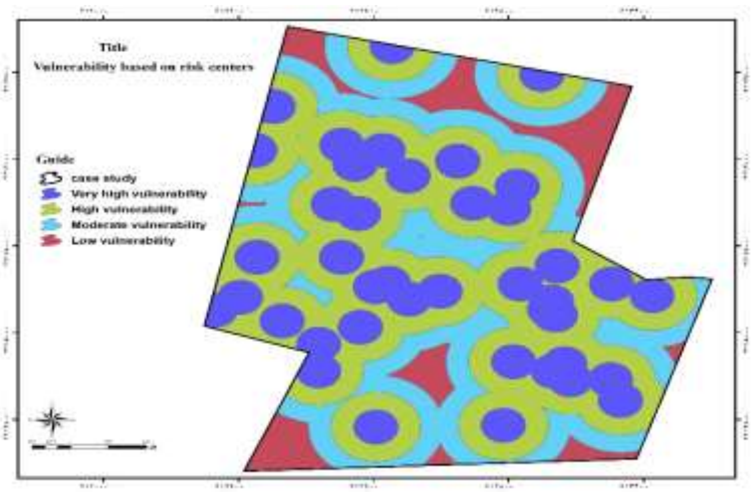

Figure 10. Vulnerability Classes Indicators of distance from Dangerous Centers

3.6. Exploring How to Access Urban Open Spaces and Parks and...

Urban open spaces are not necessarily designed to assist in earthquake conditions but are multipurpose spaces that are constructed on different scales in terms of size and performance.

Large city parks can be used as operational aid bases and, if possible, large campgrounds. (Azizi, 2004). Therefore, it can be concluded that the existence of open spaces in cities and their usability in the event of an earthquake, including easy access, avoiding hazardous use, high-performance capabilities, play an important role in reducing earthquake injuries and casualties.

Table 7. Value of each of the vulnerability classes based on the index of open space access

Percentage	Area (m 2)	floors
34.16	1375553	Low vulnerability
40.25	1620812	Moderate vulnerability
18.11	729404.1	High vulnerability
9.37	300940.3	Very high vulnerability

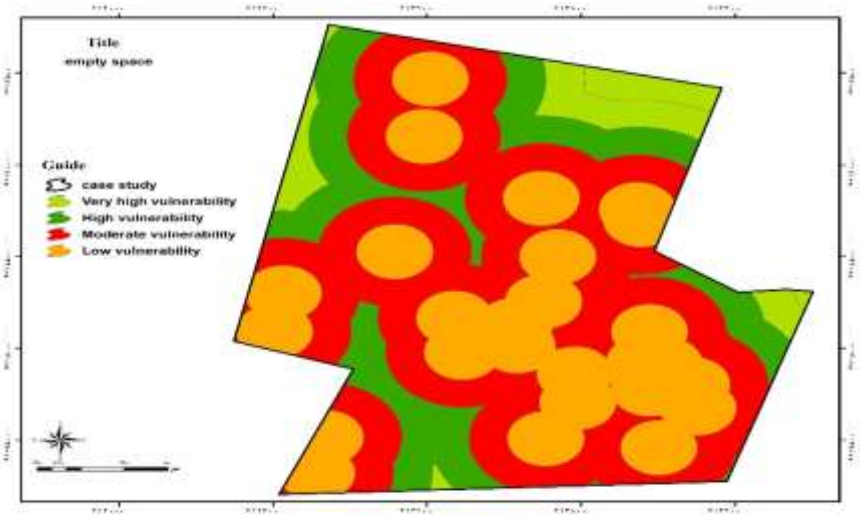

Figure 11. Vulnerability indexes for access to urban open spaces

3.7. Distribution and Distribution of Important Care and Treatment Centers:

What is derived from the status information and the vulnerability map is the spatial distribution of the relief centers in the region as desired and according to the map there are no vulnerabilities.

Table 8. distribution and Distribution of Important Care

Percentage	Area (m 2)	floors
62.35	2510494	Very low vulnerability
36.78	1481037	Low vulnerability
0.87	35178.04	Relatively vulnerable

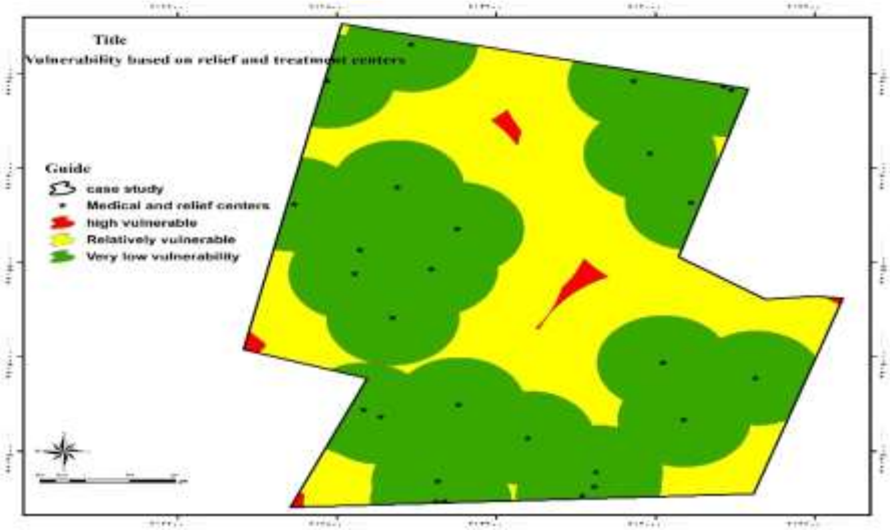

Figure 12. distribution and Distribution of Important Care

3.8. Passage ratio to city level

Considering the total area of the road network in the 8th district of Tabriz, which is 78208 square meters, this area constitutes 19% of the total area. Since at least 25% of the total land area of the city must belong to the communication network, in this regard, District 8 of Tabriz is facing a major problem, considering that the area in question is located in the central and commercial part of the city. Will double the 5-5 spatial distribution map of the passages along with its hierarchy.

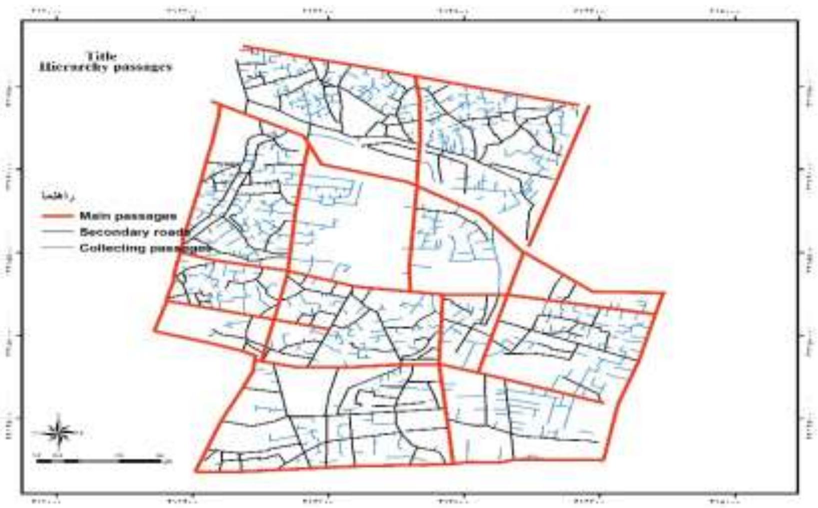

Figure 13. Passage ratio to city level

3.9. Analytical Hierarchy Process (AHP)

The AHP method has been suggested by Clock [16], which is a flexible and quantitative method of choice based on their relative performance over a number of favorite criteria (Boroushaki et al., 2008). AHP makes complex decisions through an alternatives structure that solves a hierarchical framework, and the basis of the AHP method is based on pairwise or pairwise comparisons of alternatives and decision criteria. At this stage, the scores for each indicator are obtained using the hierarchical analysis method, which gives the final scores below.

Table 9. Matrix of Preference Values, Paired Comparison of Criteria and Weight of Criteria

Criteria	Uses	Population density	Building density	Structural features	Distance from hazardous	Access to the network of passages	Access to open spaces	Access to relief centers	Micronutrient	Building quality	Age of the building	CR
Weight	0.102	0.218	0.113	0.098	0.064	0.084	0.05	0.033	0.016	0.134	0.071	0.09

3.10. Using the fuzzy-TOPSIS model

The TOPSIS method was first introduced in 1981 by Hong and Yoon. According to this model, each selected factor should have the minimum distance with the ideal factor and the maximum distance with the ideal negative factor. And that is the criteria for ranking and prioritizing factors, the best option or factor should be the closest to the positive ideal and the farthest to the negative ideal (Boroushaki et al., 2008). In short, the ideal positive factor is the best value and the negative factor the worst value. Kahraman et al., 2003; Kulak et al., 2005).

Chen et al. (2007) developed the TOPSIS method based on the fuzzy set of value values in decision making analysis. Shih and colleagues investigated the TOPSIS method in a group Decision-making environment.

In this study, fuzzy triangular numbers are used. The reason for using triangular numbers is that it makes it easy for Decision-makers to use and calculate. In addition, it has been proven using triangular fuzzy modeling that Formulating decision problems where information is subjectively available and inaccurate is an effective way Kahraman et al., 2004; Zimmerman, 1996; Chang et al., 2002; Chang et al., 2007). In scientific applications, the triangular form of the membership function is often represented. Fuzzy Numbers Used (wang, 2007) in this project, triangular fuzzy numbers are used in Fuzzy TOPSIS Figure 14 shows the triangular fuzzy numbers as($\mathbf{a_1}, \mathbf{a_2}, \mathbf{a_3}$)

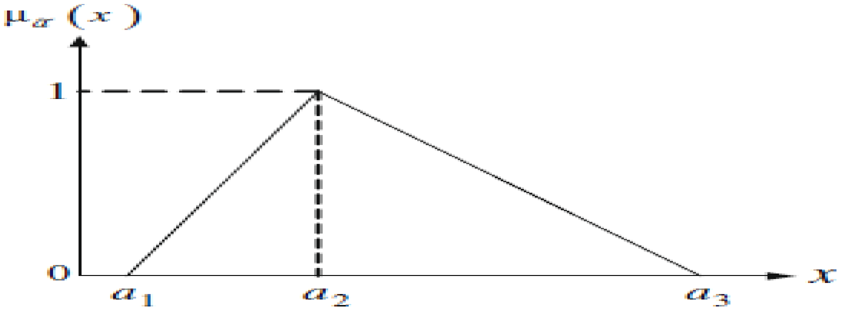

Figure 14. Triangular fuzzy numbers

a Degree of membership of each of these numbers in relation to (1)

$$\text{triangle}\ (a_1, a_2, a_3) = \begin{cases} 0 & x < a_1 \\ \dfrac{x - a_1}{a_2 - a_1} & a_1 \le x \le a_2 \\ \dfrac{a_3 - x}{a_3 - a_2} & a_2 \le x \le a_3 \\ 0 & x > a_3 \end{cases} \qquad (1)$$

If$\tilde{a}(a_1, a_2, a_3)$ and $\tilde{b}(b_1, b_2, b_3)$ are two triangular numbers, the mathematical relations of these two numbers are as follows:

ã(+) b̃=(a_1,a_2,a_3)(+)(b_1,b_2,b_3)=[(a_1+b_1),(a_2+b_2),(a_3+b_3)] (2)
a−b=a1,a2,a3−b1,b2,b3 =a1−b1,a2−b2,a3−b3 (3)
a×b=a1,a2,a3×b1,b2,b3=a1×b1),a2×b2,(a3×b3 (4)
a÷b=a1,a2,a3÷b1,b2,b3=a1÷b3,a2÷b2,a3÷b1 (5)
ka=ka1,ka2,ka3 (6)

Then have been converted the linguistic variables into triangular numbers according to figure (15).

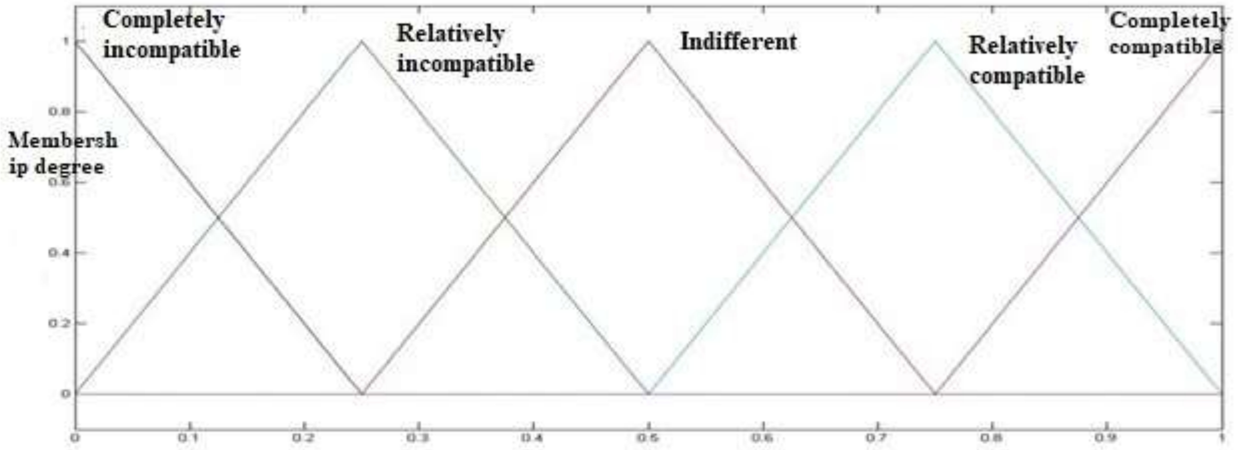

Figure 15. Linguistic values for linguistic variables

In this step, after converting the linguistic variables into triangular numbers, have been multiplied these numbers by the expert-level AHP method for obtaining the fuzzy weight, according to Table (10) below. Shown.

Table 10. Matrix Formulation of Fuzzy Numerical Components and Fuzzy Weight Gain

Uses								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight(AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.102	0.0765	0.102	0.102
very	(0.5 0.75 1)	0.5	0.75	1	0.102	0.051	0.0765	0.102
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.102	0.0255	0.051	0.0765
Low	(0 0.25 0.5)	0	0.25	0.5	0.102	0	0.0255	0.051
Population density								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight(AHP)	a1	a2	a3
Very much	(0.75 1 1)	a1	a2	a3	Weight	a1	a2	a3
very	(0.5 0.75 1)	0.75	1	1	0.187	0.14025	0.187	0.187
medium	(0.25 0.5 0.75)	0.5	0.75	1	0.187	0.0935	0.14025	0.187
Low	(0 0.25 0.5)	0.25	0.5	0.75	0.187	0.04675	0.0935	0.14025
Building density								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.093	0.06975	0.093	0.093
very	(0.5 0.75 1)	0.5	0.75	1	0.093	0.0465	0.06975	0.093
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.093	0.02325	0.0465	0.06975
Low	(0 0.25 0.5)	0	0.25	0.5	0.093	0	0.02325	0.0465
Structural features								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight(AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.098	0.0735	0.098	0.098
very	(0.5 0.75 1)	0.5	0.75	1	0.098	0.049	0.0735	0.098
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.098	0.0245	0.049	0.0735
Low	(0 0.25 0.5)	0	0.25	0.5	0.098	0	0.0245	0.049
Distance from hazardous centers								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.064	0.048	0.064	0.064
very	(0.5 0.75 1)	0.5	0.75	1	0.064	0.032	0.048	0.064
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.064	0.016	0.032	0.048
Low	(0 0.25 0.5)	0	0.25	0.5	0.064	0	0.016	0.032
Access to the network of passages								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.063	0.04725	0.063	0.063
very	(0.5 0.75 1)	0.5	0.75	1	0.063	0.0315	0.04725	0.063
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.063	0.01575	0.0315	0.04725
Low	(0 0.25 0.5)	0	0.25	0.5	0.063	0	0.01575	0.0315
Access to open spaces								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.025	0.01875	0.025	0.025
very	(0.5 0.75 1)	0.5	0.75	1	0.025	0.0125	0.01875	0.025
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.025	0.00625	0.0125	0.01875
Low	(0 0.25 0.5)	0	0.25	0.5	0.025	0	0.00625	0.0125

Access to relief centers								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.052	0.039	0.052	0.052
very	(0.5 0.75 1)	0.5	0.75	1	0.052	0.026	0.039	0.052
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.052	0.013	0.026	0.039
Low	(0 0.25 0.5)	0	0.25	0.5	0.052	0	0.013	0.026
Micronutrient								
Linguistic variables	Triangular Fuzzy numbers	a1	a2	a3	Weight (AHP)	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.024	0.018	0.024	0.024
very	(0.5 0.75 1)	0.5	0.75	1	0.024	0.012	0.018	0.024
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.024	0.006	0.012	0.018
Low	(0 0.25 0.5)	0	0.25	0.5	0.024	0	0.006	0.012
Old building								
Linguistic variable	Triangular Fuzzy numbers	a1	a2	a3	weight	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.071	0.053	0.071	0.071
very	(0.5 0.75 1)	0.5	0.75	1	0.071	0.036	0.053	0.071
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.071	0.018	0.036	0.053
Low	(0 0.25 0.5)	0	0.25	0.5	0.071	0.000	0.018	0.036
Quality of the building								
Linguistic variable	Triangular Fuzzy numbers	a1	a2	a3	weight	a1	a2	a3
Very much	(0.75 1 1)	0.75	1	1	0.134	0.101	0.134	0.134
very	(0.5 0.75 1)	0.5	0.75	1	0.134	0.067	0.101	0.134
medium	(0.25 0.5 0.75)	0.25	0.5	0.75	0.134	0.034	0.067	0.101
Low	(0 0.25 0.5)	0	0.25	0.5	0.134	0.000	0.034	0.067

After forming the decision matrix with fuzzy numerical components in the next step by using the TOPSIS method have been obtained the distance of each zoning criterion from ideal to negative and for each criterion information layers create distance from ideal to negative Can be obtained as follows, if W = (w ,) is the criterion vector weighted by condition , obtained by pairwise 1 . . . ,wm ∑ m j=1 Wj = 1 comparisons, and T is a decision matrix for risk zoning in which a˜ is a triangular number that considers ij the preference of class I of criterion j over class expert shows. By multiplying W in each of the components of column j of the matrix T, it is formed by the relation of j matrix V to the components of v˜ W) . Since the fuzzy numbers used have a scale, there is no ij = (j (×) a˜ ij need to normalize.

$$T = \begin{bmatrix} \tilde{a}_{11} & \tilde{a}_{12} & \cdots & \tilde{a}_{1j} \\ \tilde{a}_{21} & \tilde{a}_{22} & \cdots & \tilde{a}_{2j} \\ \vdots & \vdots & \ldots \vdots & \vdots \\ \tilde{a}_{i1} & \tilde{a}_{i2} & \cdots & \tilde{a}_{ij} \end{bmatrix}$$

The equations (9) and (10) represent the vector of positive and negative matrix V alternatives, respectively.

$$A^{+} = \left(\tilde{v}_1^{max}, \tilde{v}_2^{max}, \ldots, \tilde{v}_j^{max}\right) \tag{9}$$

$$A^{-} = \left(\tilde{v}_1^{min}, \tilde{v}_2^{min}, \ldots, \tilde{v}_j^{min}\right) \tag{10}$$

By subtracting each of the components of matrix V from $\tilde{v}_j^{max}$ (relation 11) and dividing the set of components of each fuzzy number by 3 (relation 12), the matrix of distance from positive ideal ($D^{+} = (d_{ij}^{+})$) (relation 14) to relation (12) and (13) It follows that in these terms d_{ij}^{+} is the distance from class I to the criterion j of the positive ideal j.

$$\tilde{d}_{ij}^{+} = \tilde{v}_j^{\max}(-)\tilde{v}_{ij} \tag{12}$$

$$d_{ij}^{+} = \frac{d_{ij_1}^{+} + d_{ij_2}^{+} + d_{ij_3}^{+}}{3} \tag{13}$$

$$D^{+} = \begin{bmatrix} d_{11}^{+} = \dfrac{d_{11_1}^{+} + d_{11_2}^{+} + d_{11_3}^{+}}{3} & d_{12}^{+} & \dots & d_{1j}^{+} \\ d_{21}^{+} & d_{22}^{+} & \dots & d_{2j}^{+} \\ \vdots & \vdots & \dots \vdots & \vdots \\ d_{i1}^{+} & d_{i2}^{+} & \dots & d_{ij}^{+} \end{bmatrix} \tag{14}$$

The distance matrix from the negative ideal (D^{-}) (relation 17) is also obtained through the relations (15 and 16) where in this relation d_{ij}^{-} is the class distance i from the criterion j to the negative ideal j.

$$\tilde{d}_{ij}^{-} = \tilde{v}_{ij}(-)\tilde{v}_j^{\min} \tag{15}$$

$$d_{ij}^{-} = \frac{d_{ij_1}^{-} + d_{ij_2}^{-} + d_{ij_3}^{-}}{3} \tag{16}$$

$$D^{-} = \begin{bmatrix} d_{11}^{-} = \dfrac{d_{11_1}^{-} + d_{11_2}^{-} + d_{11_3}^{-}}{3} & d_{12}^{-} & \dots & d_{1j}^{-} \\ d_{21}^{-} & d_{22}^{-} & \dots & d_{2j}^{-} \\ \vdots & \vdots & \dots \vdots & \vdots \\ d_{i1}^{-} & d_{si2}^{-} & \dots & d_{ij}^{-} \end{bmatrix} \tag{17}$$

Table 11. Calculating the Criterion Distance from Ideal Positive to Negative Ideal

Uses														
floors	V*			d̃_ij^+			v-			d̃_ij^-			D*	D-
	a1	a2	a3	a1	a2	a3	a1	a2	a3	a1	a2	a3	0	0.068
very much	0.077	0.102	0.102	0	0	0	0	0.026	0.051	0.077	0.077	0.051	0.017	0.051
very	0.077	0.102	0.102	0.026	0.026	0.000	0	0.026	0.051	0.051	0.051	0.051	0.043	0.026
medium	0.077	0.102	0.102	0.051	0.051	0.026	0	0.026	0.051	0.026	0.026	0.026	0.068	0.000
low	0.077	0.102	0.102	0.077	0.077	0.051	0	0.026	0.051	0.000	0.000	0.000		
Population density														
floors	V*			d̃_ij^+			v-			d̃_ij^-			D*	D-
very much	0.140	0.187	0.187	0	0	0	0	0.047	0.094	0.140	0.140	0.094	0	0.125
very	0.140	0.187	0.187	0.047	0.047	0.000	0	0.047	0.094	0.094	0.094	0.094	0.031	0.094
medium	0.140	0.187	0.187	0.094	0.094	0.047	0	0.047	0.094	0.047	0.047	0.047	0.078	0.047
low	0.140	0.187	0.187	0.140	0.140	0.094	0	0.047	0.094	0.000	0.000	0.000	0.125	0
Building density														
floors	V*			d̃_ij^+			v-			d̃_ij^-			D*	D-
very much	0.070	0.093	0.093	0	0	0	0	0.023	0.047	0.070	0.070	0.047	0	0.062
very	0.070	0.093	0.093	0.023	0.023	0.000	0	0.023	0.047	0.047	0.047	0.047	0.016	0.047
medium	0.070	0.093	0.093	0.047	0.047	0.023	0	0.023	0.047	0.023	0.023	0.023	0.039	0.023
low	0.070	0.093	0.093	0.070	0.070	0.047	0	0.023	0.047	0	0	0.000	0.062	0

Structural features

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.074	0.098	0.098	0	0	0	0	0.025	0.049	0.074	0.074	0.049	0	0.065
very	0.074	0.098	0.098	0.025	0.025	0.000	0	0.025	0.049	0.049	0.049	0.049	0.016	0.049
medium	0.074	0.098	0.098	0.049	0.049	0.025	0	0.025	0.049	0.025	0.025	0.025	0.041	0.025
low	0.074	0.098	0.098	0.074	0.074	0.049	0	0.025	0.049	0	0	0.000	0.065	0

Distance from hazardous centers

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.048	0.064	0.064	0	0	0	0	0.016	0.032	0.048	0.048	0.032	0	0.043
very	0.048	0.064	0.064	0.016	0.016	0	0	0.016	0.032	0.032	0.032	0.032	0.011	0.032
medium	0.048	0.064	0.064	0.032	0.032	0.016	0	0.016	0.032	0.016	0.016	0.016	0.027	0.016
low	0.048	0.064	0.064	0.048	0.048	0.032	0	0.016	0.032	0	0	0.000	0.043	0

Access to the network of passages

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.047	0.063	0.063	0	0	0	0	0.016	0.032	0.047	0.047	0.032	0	0.042
very	0.047	0.063	0.063	0.016	0.016	0.000	0	0.016	0.032	0.032	0.032	0.032	0.011	0.032
medium	0.047	0.063	0.063	0.032	0.032	0.016	0	0.016	0.032	0.016	0.016	0.016	0.026	0.016
low	0.047	0.063	0.063	0.047	0.047	0.032	0	0.016	0.032	0.000	0.000	0.000	0.042	0

Access to open spaces

floors		V*			d̃_ij^+			v-			d̃_ij^-		D*	D-
very much	0.019	0.025	0.025	0	0	0	0	0.006	0.013	0.019	0.019	0.013	0	0.017
very	0.019	0.025	0.025	0.006	0.006	0.000	0	0.006	0.013	0.013	0.013	0.013	0.004	0.013
medium	0.019	0.025	0.025	0.013	0.013	0.006	0	0.006	0.013	0.006	0.006	0.006	0.010	0.006
low	0.019	0.025	0.025	0.019	0.019	0.013	0	0.006	0.013	0.000	0.000	0.000	0.017	0

Access to relief centers

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.039	0.052	0.052	0	0	0	0	0.013	0.026	0.039	0.039	0.026	0	0.035
very	0.039	0.052	0.052	0.013	0.013	0	0	0.013	0.026	0.026	0.026	0.026	0.009	0.026
medium	0.039	0.052	0.052	0.026	0.026	0.013	0	0.013	0.026	0.013	0.013	0.013	0.022	0.013
low	0.039	0.052	0.052	0.039	0.039	0.026	0	0.013	0.026	0.000	0.000	0.000	0.035	0

Micronutrient

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.018	0.024	0.024	0	0	0	0	0.006	0.012	0.018	0.018	0.012	0	0.016
very	0.018	0.024	0.024	0.006	0.006	0	0	0.006	0.012	0.012	0.012	0.012	0.004	0.012
medium	0.018	0.024	0.024	0.012	0.012	0.006	0	0.006	0.012	0.006	0.006	0.006	0.01	0.006
low	0.018	0.024	0.024	0.018	0.018	0.012	0	0.006	0.012	0	0	0.000	0.016	0

Building quality

floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.101	0.134	0.134	0	0	0	0	0.034	0.067	0.101	0.101	0.067	0	0.089
very	0.101	0.134	0.134	0.034	0.034	0.000	0	0.034	0.067	0.067	0.067	0.067	0.022	0.067
medium	0.101	0.134	0.134	0.067	0.067	0.034	0	0.034	0.067	0.034	0.034	0.034	0.056	0.034
low	0.101	0.134	0.134	0.101	0.101	0.067	0	0.034	0.067	0.000	0.000	0.000	0.089	0.000

Old building														
floors			V*			d̃_ij^+			v-			d̃_ij^-	D*	D-
very much	0.053	0.071	0.071	0	0	0	0	0.018	0.036	0.053	0.053	0.036	0	0.047
very	0.053	0.071	0.071	0.018	0.018	0	0	0.018	0.036	0.036	0.036	0.036	0.012	0.036
medium	0.053	0.071	0.071	0.036	0.036	0.018	0	0.018	0.036	0.018	0.018	0.018	0.030	0.018
low	0.053	0.071	0.071	0.053	0.053	0.036	0	0.018	0.036	0	0	0.0	0.047	0

The relative closeness of each option to the ideal solution (RCi) is obtained by using (18). By integrating the positive and negative ideal layers into the GIS environment, the final layer is formed and the finalization of the options is based on it. In this respect m is the number of criteria.

$$\mathrm{RC_i} = \frac{\sum_{j=1}^{m} d_{ij}^{-}}{\sum_{j=1}^{m} d_{ij}^{-} + \sum_{j=1}^{m} d_{ij}^{+}} \qquad (18)$$

According to the results of the calculation of land pixels according to relation (18) in GIS environment show that 22.98% of the area with high risk, 37.38% with high risk, 21.53% with medium risk, and 18.11% with high risk. It is less wavy.

Table 12: Area risk level of Tabriz Region 8

Components	Number of pixels	Area of each pixel	Area of each floor	Percentage
Too much risk	28783	25	719575	22.98
High risk	46813	25	1170325	37.38
Moderate Risk	26972	25	674300	21.53
Low risk	22682	25	567050	18.11
Too much risk	28783	25	719575	22.98

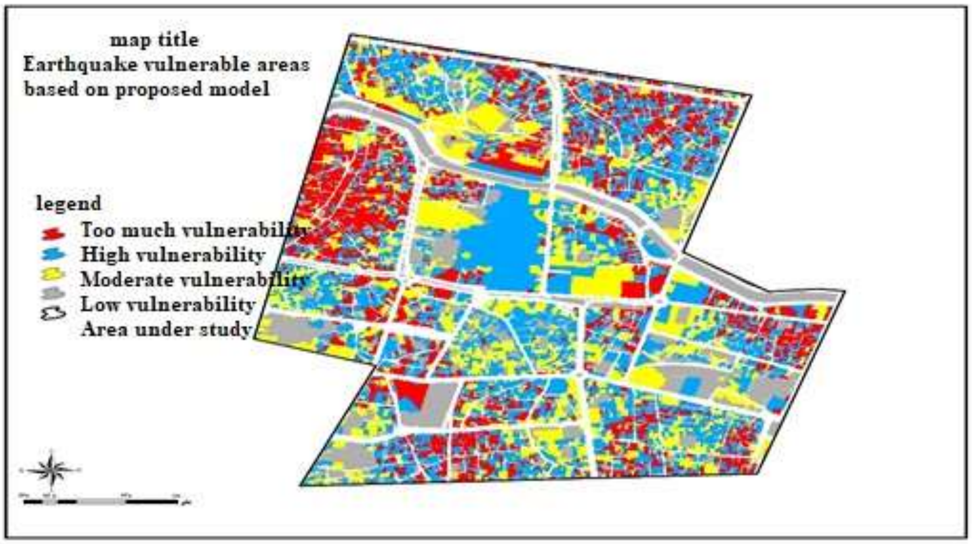

Figure 16. Final map of Tabriz city hazard zoning using fuzzy logic combined with AHP, TOPSIS (proposed method)

4. Conclusion

According to the final hazard zoning map, the areas with a high level of hazard include a higher percentage, the area of which includes the old and worn-out texture of the city of Tabriz. As a result, depending on the social, economic and physical conditions of this area, the risk level is several times higher than in other areas. On the other hand, all of these neighborhoods are more vulnerable than other areas of the city because of poor access and high population density. As a result, the vulnerability of this area to the city of Tabriz during the earthquake is very high due to physical and urban planning issues and after the earthquake due to cultural and social issues.

Ahadnezhad, Mohsen et al. (2010) presented an article on the modeling of urban structural vulnerability to earthquake using a hierarchical analysis process in GIS environment with a case study of Zanjan city.

The results of this paper show that the area of three cities of Zanjan and the buildings located in Zanjan due to texture burnout and the use of durable materials in construction and long life of buildings are highly vulnerable.

Elhamian (2005) in his master's thesis studies the location of multipurpose spaces in relation to the Tehran earthquake risk from the geographical point of view. Not given. In this paper, by combining decision-making models, the results of the research are attempted to be more accurate, in fact first by using an expert weighting of criteria through AHP, then by using the fuzzy logic of qualitative components quantitatively. Has become, this method has made the results more objective and in the last stage using the TOPSIS model the best possible result has been achieved. Estimate the risk of Tabriz Region 8.

Estimation and estimation of risk and crisis requires a holistic approach in which to utilize various specialties such as urban planning. Loss reduction policies are in place. In such a case, based on a rationalist approach, through the use of different criteria in the macro and micro scales, it is possible to combine complex, multidimensional variables and criteria that are of low quality together to produce a rational result. Such an evaluation process works by identifying the criteria that affect a system, based on a hierarchical structure, and by applying vulnerability assessment relationships and determining the coefficients of the importance of each criterion over the other criteria. Results show that northwest of the region has the highest risk according to selected criteria. Tabriz Region 8 given the historical context and the old context, various plans must be made to revive it, especially the various crisis management and earthquake vulnerability planning for this area.

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