Doi: 10.32592/jorar.2022.14.4.3

Vulnerability Analysis of Urban Texture in Earthquakes: A Case Study of District 2 of Tabriz City

Omid Mobaraki[1], **Abdollah Jodat**[2]

Date of submission: 14 Sep. 2020 *Date of acceptance: 02 Aug. 2022*

Original Article

Abstract

INTRODUCTION: Natural disasters are known as one of the most important factors in the destruction of human settlements. One of the key concerns for urban planners is examining how natural disasters affect human settlements, particularly cities. Earthquake is one of these natural disasters that has always threatened human settlements and can cause a lot of damage and casualties in a short period. Therefore, this study aimed to assess the vulnerability of settlements in district 2 of Tabriz, Iran, against earthquakes.

METHODS: This applied research was conducted based on a descriptive-analytical approach. The primary data of existing documents and maps were collected from related organizations. The analytical hierarchy process model and geographic information system software were used for data analysis.

FINDINGS: To determine the vulnerability of the texture of district 2 of Tabriz, such indicators as the distance from the fault, slope percentage, groundwater levels, building age, building materials, building quality, building density, number of floors, plot area, and land use were employed.

CONCLUSION: According to the results, 35% of the region was in the high-risk and 25% in the very high-risk areas. In general, it can be said that most of the region (i.e. 60%) was in the area with a high risk of earthquake, and the area with very high risk was mostly in the northern parts of the region, while the southeastern parts of the region were located in low-risk areas.

Keywords: District 2 of Tabriz; Earthquake; GIS software; Urban texture; Vulnerability

How to cite this article: Mobaraki O, Jodat A. **Vulnerability Analysis of Urban Texture in Earthquakes: A Case Study of District 2 of Tabriz City.** Sci J Rescue Relief 2022; 14(4): 258-268.

Introduction

In the past few decades, casualties caused by earthquakes have not decreased, but in general, with the growth of urbanization, 10,000 people have been added to this number in each decade (1).

Today, despite the advancements in technology and an increase in human knowledge and ability to control natural disasters, cities are still facing these risks and are vulnerable in this regard. Therefore, increasing the safety of cities in the face of these dangers is highly important, although the techniques of securing cities against all types of damage have changed considerably compared to the past. Undoubtedly, one of the effective factors in reducing the vulnerability of cities, especially damages caused by earthquakes, is the shape and structure of cities (2).

Among the various levels of planning, in the sub-group of physical planning, the most efficient level to reduce the vulnerability of cities to unexpected events is the middle level or urban planning. The poor condition of the establishment of physical elements, inappropriate uses of urban land, inefficient communication network of the city, congested urban textures, high densities, condition of the establishment of the city's infrastructure facilities, lack and inappropriate distribution of urban open spaces, and such issues play a major role in increasing the extent of damages to cities against unexpected events; therefore, what turns these events into a disaster in numerous cases is the inappropriate state of urban

1- Assistant professor University of Maragheh, University of Maragheh, Iran
2- MA in Urban Planning, University of Marand, Iran
Correspondence to: Omid Mobaraki, Email: omidmobaraki@gmail.com

development (3).

The texture of the city, as one of the elements of the city shape, determines the size and composition of the smallest components of the city. Every type of urban texture has a certain amount of resistance against unexpected events, such as earthquakes. The reaction of any type of urban texture during an earthquake has a direct impact on the residents' ability to escape and seek refuge, the assistance facilities, how to clean and rebuild, and even temporary accommodation (4). According to the fact that 20 out of 43 unexpected disasters in the world have occurred in Tabriz city, Iran, so far and that this city is located on the Alpine orogeny belt, where land disturbances are one of the characteristics of this type of orogeny, this region has become prone to natural disasters, such as earthquakes (5).

The study of the history of earthquakes in the historical writings also shows the existence of seismic activity in the area of Tabriz since 634 AD, which destroyed Tabriz four times due to earthquakes between 1641-1780 that is, in less than 140 years. However, since then, more than 219 years of relative peace have reigned over this old city, and according to Emmanuel Berberian, the longer this break in the occurrence of destructive earthquakes, the more destructive the power of an earthquake that is naturally expected to happen (6). In addition to the great potential of this city for natural disasters, such as earthquakes, and considering that most of the texture of Tabriz city consists of worn-out, marginal areas with high population density and narrow roads the possibility of access greatly reduces when disasters occur (7).

Given the increase in the occurrence of natural disasters, especially earthquakes, in recent years in different parts of the world, and as a result, the rise in damages caused by these phenomena, the issues of reducing damages caused by accidents and increasing resistance and preparedness against them have gained special importance. The United Nations named the 1990s the International Decade for Natural Disaster Reduction, during which time comprehensive studies and research were conducted to understand the effects of disasters in different regions of the world to reduce damages caused by disasters (8).

Geographical data is highly important in investigating the vulnerability of an area and is considered a guide for urban disaster prevention planning. In practice, the lack of data is the most serious problem for conducting such studies, especially in developing countries (9). Therefore, one of the goals of urban planning to prevent disasters is to identify the process of disastrous elements and strengthen the safety of the environment, through the modification and improvement of the city and urban development (3). One of the most important measures to reduce the risks caused by earthquakes and increase public safety is conducting seismic zoning studies of urban areas and determining the degree of vulnerability of various buildings in the city. This should be done on an appropriate and desirable scale, being accomplished using the Geographic Information System (GIS) software for buildings at different levels of vulnerability (10).

In July of 2007, in a contract between the Housing and Urban Development Organization of East Azarbaijan province and the consulting engineers of Tehran Padir, the seismic risk-zoning plan of the city of Tabriz was assigned to this consultant. This plan, which mostly emphasized geotechnical investigations and a brief study on crisis management and earthquake effects in connection with urban development based on 12 physical and social criteria, dealt with earthquake risk zoning in Tabriz city.

Unfortunately, due to the lack of detailed and expert studies, environmental factors and criteria were not examined in this study, and the 12 mentioned criteria were overlapped without using rating models, and in fact, all elements were considered with the same score, which according to the mentioned items, it was not possible to assume a scientific basis for this study and plan. The results indicated a very high risk in the peripheral and central areas of the city and a decrease in the risk in the western and southwestern parts of the city. It should be noted that this plan predicted a maximum of 426,000 deaths in the event of an earthquake in this city.

Zangiabadi et al. in an article titled "Analysis and Assessment of Vulnerability factors in the city against Earthquake (case study: Tehran district 4)", using the Analytic Hierarchy Process (AHP) as the main model, as well as the capabilities and analytical techniques of GIS software, such as the overlap of the layers, have concluded that in addition to environmental (tectonic) or physical factors, other factors, such as social and economic factors, have an effect in increasing the damages caused by earthquakes (11).

Mobaraki et al. in an article titled "Assessment of the Vulnerability of Urban Housing to Earthquakes (Case Study: Azar Shahr city)", using the AHP model with pairwise comparisons and ARC GIS software in the phases related to data entry, storage, management, processing, and analysis considered such criteria as the distance from the fault, slope percentage, soil type, population density, building quality, building material, the age of the building, number of floors, access to open spaces, distance from the hospital, and distance from the fire station. Examining the results obtained from this research shows that different factors can have different effects on the damages caused by the earthquake. Accordingly, since the city of Azadshahr is located at a distance of 9 km from the fault area, in the epicenter of the earthquake, and considering the mentioned criteria and analyzing them, the level of physical vulnerability is high in the suburbs of the city, and due to the high density of buildings and population, the low quality of structures and the network of organic roads in the central and old part of the city, the level of vulnerability is very high in this part (12).

This study aimed to investigate and analyze the degree of vulnerability of the urban texture of district 2 in Tabriz city. This area is one of the most important and densest areas of Tabriz city. The densely populated areas of Southern Valiasr, Parvaz, El Goli, and Zafaranieh, on the one hand, and the presence of vital and important land uses, such as Shohada Hospital, El Goli resort, various government offices, such as the office of the Ministry of Foreign Affairs, and finally, the presence of high-rise residential and service towers, such as Shahran Tower and Aseman Tabriz, proves the need to comprehensively examine this area in terms of its vulnerability to earthquakes.

Study area

Tabriz city, the capital of East Azarbaijan province and Tabriz County in northwestern Iran, is located 524 km northwest of Tehran, 135 km south of Jolfa, and 50 km northwest of Sahand Mountain. This city is located at an altitude of 1,365 m, in a temperate, cold, dry mountainous climate, and is situated in the geographical position of 46 degrees 18 minutes east longitude and 38 degrees 4 minutes 45 seconds north latitude, next to Aji Chai and the northwestern edge of Sahand Mountain. It has 12 urban areas and is located on the volcanic lands of Sahand in the south.

This area is a part of the alluvial deposits of Tabriz, which spreads from the west to Lake Urmia, and is limited on the north and northeast to the red mountain range, which consists of salt gypsy formations and other red sediments. This northern range is called Eynali Heights and its highest point is Rushdieh with a height of 1,800 m. The river that has cut these mountains and created a path is Aji Chai. The southern part of Tabriz is also limited to the foothills of Sahand. District 2 is located in the southeastern part of Tabriz city. This area overlooks districts 1 and 5 in the north, district 9 in the west, district 3 in the west, and Shahid Kasaie highway in the south. in terms of altitude, this area is located at an average height of 1,600 m. according to the latest census, the district 2 of Tabriz has a population of 154,098, out of which, 78,299 are men, and 75,799 are women. The number of households in this area is 42,327, and the size of the household is 3.64 accordingly (13).

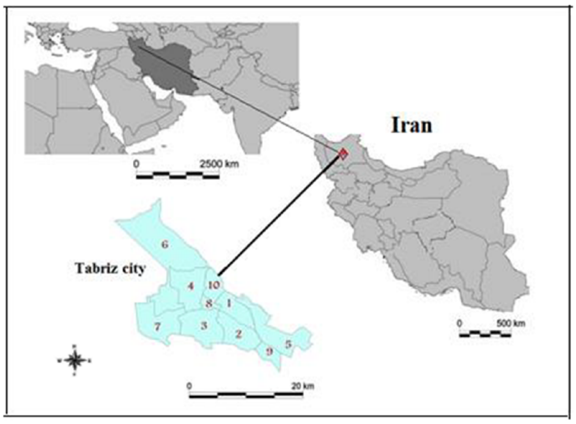

Figure 1. Map of the study area

Methods

This applied research was conducted based on the descriptive-analytical approach. At this stage, using field surveys and 1/2000 urban maps, the base map of the neighborhood was prepared in the GIS environment; afterward, the effective factors in intensifying the impacts of the earthquake needed to be identified. To carry out this step, first, using library studies and the opinions of experts, indicators related to texture seismicity were extracted, which were 1) distance from the fault, 2) slope percentage, 3) groundwater levels, 4) population density, 5) building quality, 6) building materials, and 7) distance from hazardous centers. The information layers of the mentioned indicators were also prepared in the GIS environment at the same time.

Subsequently, to score and rank the effective criteria and put them in the AHP model, an expert questionnaire was designed and distributed to the experts to be filled out. From the result of this work, the output of the AHP was extracted, which contained a table of the scores of the effective indicators. The compatibility ratio (CR) in this study was 0.07, which was an acceptable indicator of compatibility because it was smaller than 0.1. After extracting the weight, the necessary analyses were performed on the layers, and the layers were converted into appropriate raster file formats.

Table 1. Preference values for pairwise comparisons (15)

Degree of preference	Numeric value
Extremely preferred or extremely more important or extremely more desirable	9
Very strongly preferred or important or desirable	7
Strongly preferred or important or desirable	5
Moderately preferred or more important or more desirable	3
Equally preferred or important or desirable	1
Intermediate values between two adjacent judgments	2, 4, 6, 8

Table 2. Binary comparison of criteria

	Distance from the fault	Groundwater level	Slope	Building materials	Building quality	Distance from hazardous centers	Population density
Distance from the fault	1	3	4	3	4	7	7
Groundwater level		1	3	4	5	5	5
Slope			1	2	2	3	4
Building materials				1	3	5	5
Building quality					1	2	3
Distance from hazardous centers						1	3
Population density							1

To extract the final map, which contained the priority and zoning of the region's texture in relation to earthquake risk, the research indicators were overlapped in the form of information layers with the scores of the AHP model using the RC function of the ARC GIS software.

Table 3. Final score of each criterion

Criterion	Weight
Distance from the fault	0.363
Groundwater level	0.253
Slope	0.129
Building materials	0.121
Building quality	0.061
Distance from hazardous centers	0.044
Population density	0.029
Compatibility rate	0.07

Analytical Hierarchy Process

In the method of AHP, the calculations of relative weights and absolute (final) weights are performed based on the weight of the indicators in comparison with the weight of the options. Saati uses the eigenvector method to calculate the relative weight resulting from the comparison of pairs in the matrix. According to Saati, to calculate the values and eigenvector, the columns are added together and each cell of the matrix is divided by the sum of the corresponding column. The next step is to calculate the average of the rows of the matrix, which is used as a relative weight at this level (14). In the AHP method, all factors and criteria are compared two by two and placed in the matrix of weights. In this method, the comparison scale is placed in the range of 1 to 9, with the value of 1 indicating the importance equal to two factors and the number 9 indicating the extremely important importance of one factor compared to another factor.

This method includes three main steps, namely

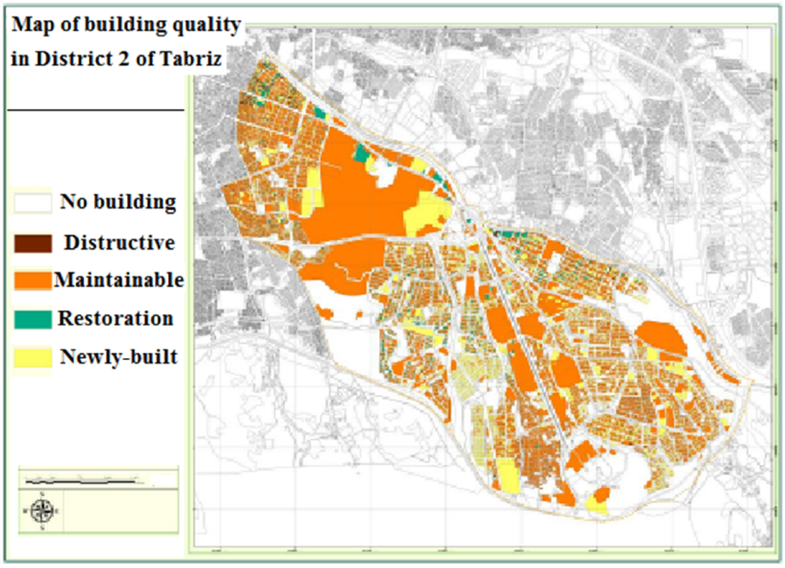

Figure 2. Map of building quality in district 2 of Tabriz

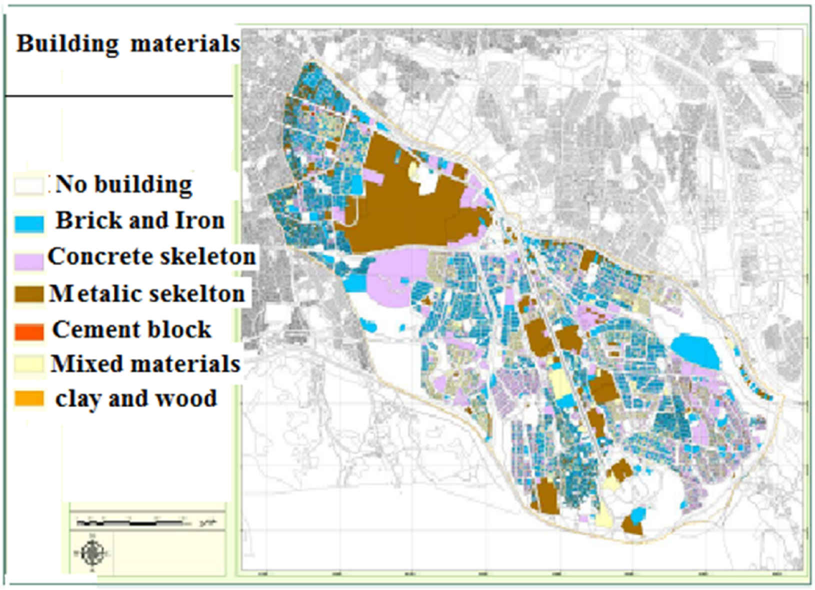

Figure 3. Materials used in buildings

a) generation of pairwise comparison matrix, b) calculation of criterion weights, and c) estimation of agreement ratio (16). After determining the effective factors in the vulnerability of areas, at this stage, the indicators were measured against each other, and after checking the sub-criteria, using the AHP method, the importance (weight) of each in vulnerability was obtained. In this regard, in the AHP model, after forming the matrix of pairwise comparisons based on the 9-quantity scale, once the sources were studied and the characteristics of the indicators were identified, all criteria were examined and compared in relation to each other and in pairs.

Afterward, by normalizing the rows of the matrix, after being placed in the model, the priority, as well as the coefficients of importance and the score of each criterion, were determined. The CR in this study was 0.07, which was an acceptable indicator of compatibility because it was smaller than 0.1. Finally, by weighting the layers, combining, and overlapping the layers (indices) with each other, the Weighted Overlay method of the GIS was used. Using this method, the weight of each of the indicators was given in that index, and then the indicators were combined with each other. Eventually, the final map was extracted that showed the spatial distribution map of the overall vulnerability of the regions of Ahar city, East Azerbaijan Province, Iran, to the risk of earthquakes.

The absolute weight is the final rank of each option, which is obtained by combining the relative weights. The final weight of each option in a hierarchy is obtained by adding up the sum of the importance of the criteria in the weight of the options (17). The sum of the total weights for the final analysis must be equal to one. To determine the values, the factors must be checked well and their determination is not optional. If we arbitrarily set a superior value for the factor, CR will arise in the analysis. After determining the effective criteria and indicators for each of these criteria, a series of sub-criteria was prepared, and based on the existing standards, as well as the opinions of experts and specialists in this field, weights were assigned to each of these sub-criteria based on their vulnerability. According to these weights, a map of each criterion and indicator used by the GIS was prepared.

Assessment of the current condition of District 2 of Tabriz

Demographic profile

According to the latest population and housing census (2011), the district 2 of Tabriz had a population of 154,098 people. It should be noted that the demographic information was extracted from statistical blocks. Of this number, 78,299 were men and 75,799 were women. The number of households in this area was 42,327. According to this, the size of the household was 3.64 (Statistics Center of Iran). Table 4 presents the demographic characteristics of district 2.

Table 4. Demographic characteristics (13)

Population	Number of men	Number of women	Number of households	Family size
154098	78299	75799	42327	3.64

Urban land use

Considering that district 2 is part of the city's residential texture, the predominant use in this area is residential with 29.55%. Table 5 gives information about the percentage and per capita usage in district 2 of Tabriz.

Table 5. Percentage and per capita of land use in district 2 of Tabriz (18)

Row	Use	Area in meters	Percentage	Per capita
1	Hygienic	173.17	0.001	0.001
2	Religious	30743.95	0.153	0.200
3	Athletic	51092.34	0.255	0.332
4	Industrial	56958.79	0.284	0.370
5	Urban equipment	58009.05	0.289	0.376
6	Military	60889.43	0.304	0.395
7	Urban facilities	70329.81	0.351	0.456
8	River and stream	126699.50	0.632	0.822
9	Suburbs	137666.09	0.687	0.893
10	Transportation and storage	164126.73	0.819	1.065
11	Entertainment-tourism	184177.18	0.922	1.198
12	Gardens and agriculture	214826.25	1.072	1.394
13	Cultural-artistic	255232.24	1.274	1.656
14	Refuge	255292.19	1.275	1.657
15	Educational	294257.51	1.469	1.910
16	Medical	304667.16	1.535	1.997
17	Commercial	358192.52	1.788	2.324
18	Administrative and police	548607.79	2.738	3.560
19	Park	1294985.79	6.463	8.404
20	Higher education	1832371.89	9.145	11.891
21	Barren	2523224	12.592	16.374
22	Residential	5923018.27	29.559	38.437
23	Road network	5288753.65	26.394	34.321
24	Total	20037793.28	100	13.033

Table 6. Building quality in district 2 of Tabriz

Row	Building quality	Area in meters	Percentage
1	Newly-built	2349831.713	15.93
2	Maintainable	7464133.356	50.61
3	Restoration-needed	332201.844	25.2
4	Destruction-needed	50178.901	0.34
5	No building	4552693.81	30.87

Table 7. Used materials (18)

Row	Materials	Area in meters	Percentage
1	Steel structure	2782795.29	18.87
2	Concrete skeleton	2481886.60	16.83
3	Brick and iron	3245355.64	22
4	Cement block	10495.27	0.07
5	Clay and wood	4516.75	0.03
6	Mixed	1671296.27	11.33
7	No building	4552693.82	30.87

Building quality

Due to the fact that district 2 is part of the newly constructed area; most of the constructions in this area are maintainable and newly built. Table 6 shows the quality of buildings in district 2 of Tabriz.

Used Materials

Most of the constructions in this area are made of concrete and metal. Table 7 presents the materials used in district 2 of Tabriz.

Age of building

Most of the buildings in the region were built between 15 and 30 years ago, which included 21.44% of the buildings in the neighborhood. The lowest percentage was related to the buildings with an age of 5-15 years with 9.94%. Table 8 and Figure 4 give information about the age of buildings in this district.

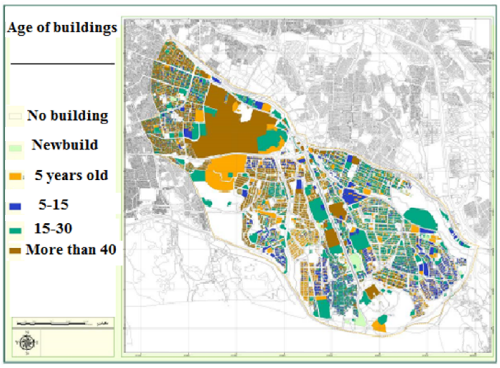

Figure 4. Age of buildings in district 2 of Tabriz

Number of floors

Most of the buildings in this neighborhood were one-story with 24.33%, and the lowest share was related to 19-story buildings with 0.3%. Regarding the distribution of the number of floors, it should be mentioned that the number of building floors in this neighborhood was from 1 to 26 floors.

Table 8. Age of buildings in district 2 of Tabriz

Row	Age of building	Area in meters	Percentage
1	Last 5 years	2182578485.173	17.48
2	5-15 years	1465818.97	94.9
3	15-30 years	3158031.15	21.41
4	30 years and above	2994010.519	30.20
5	No building	4552693.816	30.87

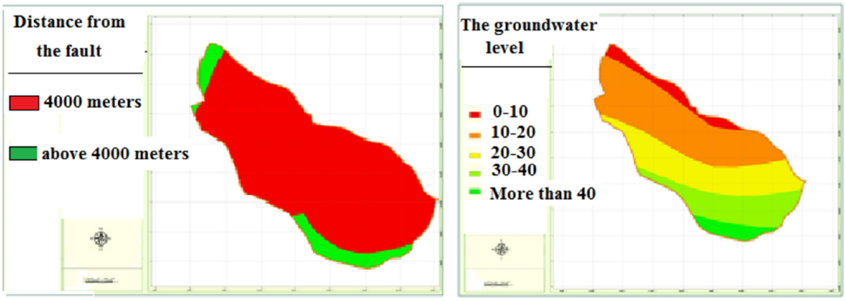

Figure 5. Distance map of the zoning of the groundwater level and zoning of the distance from the fault

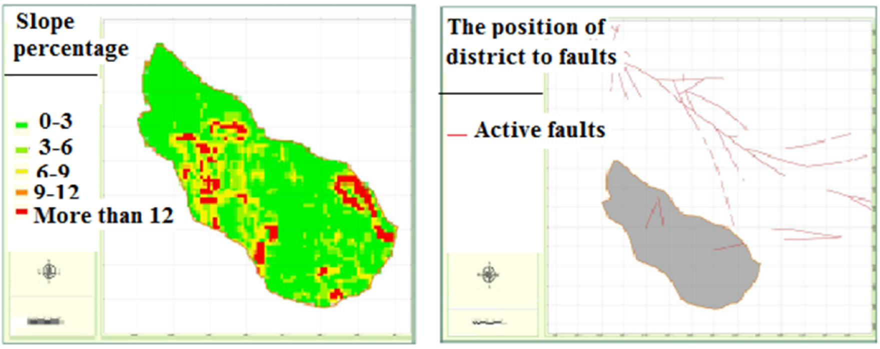

Figure 6. Map of the position of district 2 in relation to active faults and zoning of slope percentage

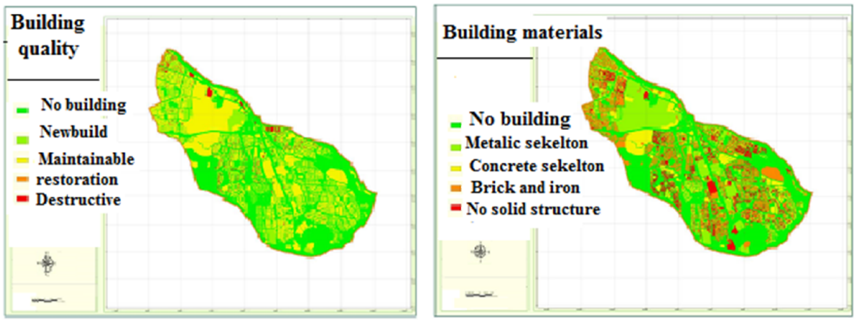

Figure 7. Map of building materials and building quality

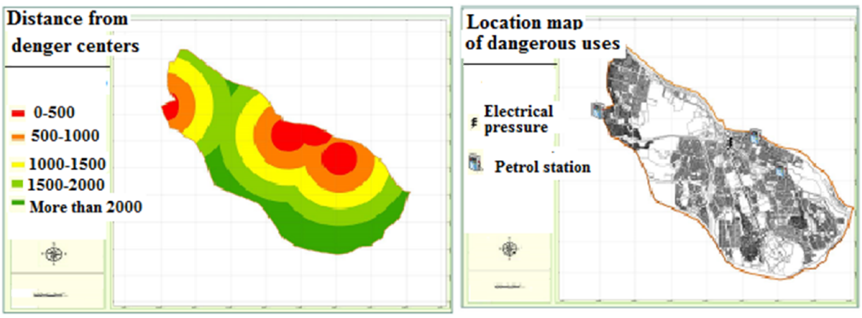

Figure 8. Location map of dangerous uses and zoning distance from danger centers

Criteria and layers needed for zoning the vulnerability of the texture of District 2

1- Distance from fault lines: considering that Tabriz is located in the vicinity of the active Tabriz fault, the distance from the fault lines should be taken into account for any investigation and research regarding the earthquake. In this research, the distance from the fault lines was also taken into account. Due to the short distance and proximity of district 2 to the active faults, the entire district 2 is located within 2 and 3 km of the active fault of Tabriz.

2- Groundwater levels: considering that the intensity of the earthquake is directly related to the groundwater levels, the level of district 2 was zoned according to the amount and level of groundwater.

3- Slope: due to the fact that increasing slope causes instability, the intensity of the earthquake is also directly related to the slope factor. District 2 is also located in an area with a variable slope.

4- Building materials: one of the most important approaches to deal with the destructive effects of an earthquake is the structural stabilization of units, and the level of structural stability has an inverse relationship with the effects of an earthquake.

5- Building quality: this is another effective factor in the impact of an earthquake, and the more we move from the newly built units to the destroyed units, the more the intensity and effect of the earthquake will be observed.

6- Distance from disastrous centers: facilities and centers, such as gas and liquid fuel stations, as well as electricity and gas substations and power plants, are among the uses and centers that in case of an explosion will intensify the effects of an earthquake. For this reason, the level of district 2 was zoned in terms of distance from these uses.

7- Population density: considering that death toll and human and social damage are among the most important aspects of earthquake damage, with the increase in population density and in fact with the increase in human presence, the probability of damage and the severity of earthquake effects also increase as well.

To estimate the overall level of vulnerability, in the end, the indicators were combined with each other, and the final map was extracted that showed the spatial distribution of the overall level of vulnerability of the district 2 texture against the risk of earthquake. According to the fact that the district 2 of Tabriz was in low to very high vulnerability in terms of most of the indicators, 4 levels were obtained in the final zoning. It can be said that there was no relatively low-risk zone in this area and this indicated a high risk of earthquake in this area.

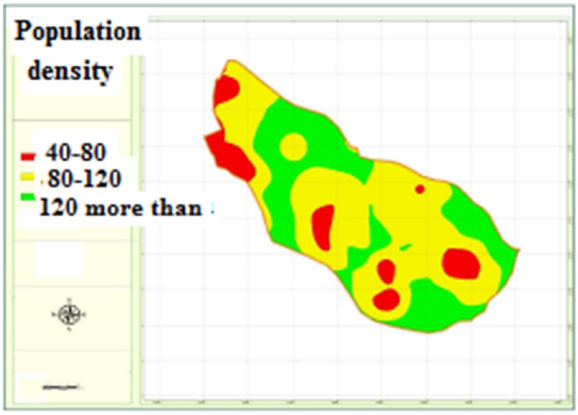

Figure 9. Population density zoning

According to Figure 10, most of district 2 was within an area of a high risk of earthquakes. Accordingly, 35% of the region was in the high-risk, 25% in the very high-risk, 28% in the moderate-risk, and only 12% in the low-risk areas. However, the important point is that all parts of the region were not in the same-level risk area. The distribution of the very high-risk areas was mostly in the northern parts of the region, while low-risk areas were in the southeastern parts of the region. In the high- and very high-risk areas, vital uses, such as Tabriz University, Tabriz International Hospital, Provincial Telecommunication Center, Program and Budget Organization Building, and Army Barracks, as well as other residential and commercial areas are located, which will make the controlling of the region difficult in critical situations and will face it with serious problems.

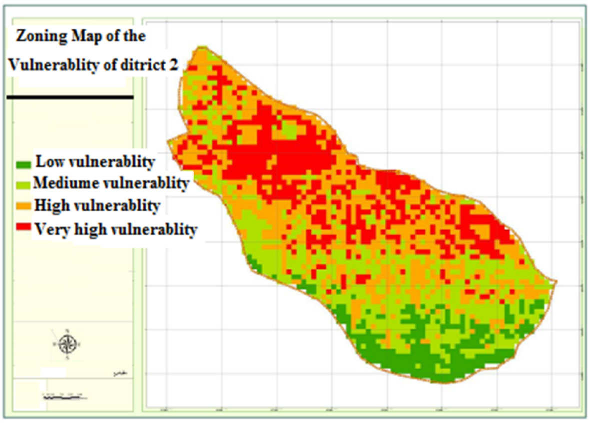

Figure 10. Final zoning map of the vulnerability of district 2 of Tabriz against earthquake risk

Discussion and Conclusion

One of the aspects of the physical planning of cities is attention to natural disasters. Natural disasters are one of the important factors in locating settlements and activities and determining land use. Iran is one of the most dangerous countries in the world in terms of natural disasters, such as earthquakes, landslides, floods, and storms. A look at the preliminary map of earthquake relative risk zoning in Iran indicates that most of the country's residential areas are in the relatively high-risk range and almost all of the country is in the relatively medium- to high-risk range. One of these bases is assessing the vulnerability of urban physical spaces and planning based on it. Given that the occurrence of earthquakes is one of the most common natural disasters that threaten urban environments, the crises caused by earthquakes have prompted researchers to take measures based on their knowledge and specialized fields and acknowledge earthquakes, their effect mechanisms, the methods of managing crises caused by them, and the methods of reducing their harmful effects.

In recent years, the knowledge of urban planning and design, in accordance with its scope, has sought to identify methods to mitigate earthquake damage in cities as the main human habitat. This study aimed to determine the vulnerability of the texture of district 2 of Tabriz against natural disasters, especially earthquakes. After determining the indicators by means of the analysis of multivariate functions, it was tried to address this issue using the results of previous studies, presenting new components and indicators, and employing the AHP model, and finally, the information output was presented in the form of a map. The results indicated that most of district 2 of Tabriz were in the area with high earthquake risk. Accordingly, 35% of the region was in the high-risk, 25% in the very high-risk, 28% in the moderate-risk, and only 12% in the low-risk areas. However, the important point is that all parts of the region were not in the same risk area. The distribution of the very high-risk areas was mostly in the northern parts of the region, while low-risk areas were in the southeastern parts of the region. In the high- and very high-risk areas, vital uses, such as Tabriz University, Tabriz International Hospital, Provincial Telecommunication Center, Program and Budget Organization Building, and Army Barracks, as well as other residential and commercial areas of the region are located, which will make the controlling of the region difficult in critical situations and will face it with serious problems.

In the end, it can be concluded that planning is a tool that takes us from the current situation to the desired situation. Therefore, it is highly recommended that this planning be performed with a more open vision and with the cooperation of all members of the society, from the people to the officials, so that we can observe the fruit of planning, and as a result, sustainable development.

Acknowledgments

None

Conflict of Interests

The authors declare that they have no conflict of interest.

References

1. Mohammadzadeh R. Investigating the role of open spaces and communication network in reducing earthquake damage, Journal of Soffeh, 2010; 50: 104-118. (In Persian).
2. Nouraei H, Rezaei N, Abbasspour R. Evaluation and spatial analysis of the effectiveness of local communication networks after the earthquake from the point of view of passive defense, Journal of Advanced Defense Science and Technology, 2011; 29: 152-164 (In Persian).
3. Abdollahi M. Crisis management in urban areas, Municipalities and Village Administrations Organization publication, 2004. (In Persian).
4. Ahmadi H. The role of urban development in reducing the vulnerability of the city against earthquakes, Journal of Housing and Rural Environment. 2000; 229: 26-35. (In Persian).
5. Azar A. Investigation and assessment of the city's vulnerability to earthquakes, urban construction conference in the vicinity of active faults. 2010. (In Persian).
6. Mogimioskuei A, Osku A. From the shore of Lake Urmia to Sahand Peak. Osku municipality publication. 2006. (In Persian).
7. Bahmani Oskuei M, Mohammadzadeh R. Assessing the degree of vulnerability to earthquakes in the Sakhanmani building of the old context of Tabriz city, Urban construction conference in the vicinity of active faults. 2010. (In Persian).
8. Pourkermani M, Arian M. Seismicity of Iran,

Publications of Shahid Beheshti University. 1998. (In Persian).
9. Taghvaei M, Alimohammadi N. Earthquake and its consequences and crises in cities, Journal of Bana. 2006; 27; 83-107. (In Persian).
10. Roca A, Goula X, Susagna T, Chavez J, Gonzalez M, Reinoso E. A simplified method for vulnerability assessment of dwelling buildings and estimation of damage scenarios in Catalonia, Spain, Springer, 2006; 12, 141-158.
11. Zangiabadi A, Varesi H, Derakhshan H. Analysis and evaluation of the city's vulnerability factors against earthquakes (case study of the 4th district of Tehran), Journal of rescue and relief. 2010; 3: 45-54. (In Persian).
12. Mobaraki O, Esmaeilpour M, Amini S. Physical vulnerability assessment of Azadshahr against earthquake, Journal of safe city, 2019; 7: 62-74. (In Persian).
13. Statistical center of Iran.2011. (In Persian)
14. Saaty, T.L. The Analytic Hierarchy Process، Planning, Priority Setting, Resource Allocation. McGraw-Hill, New York, NY. 1980
15. Godsipour H. Analytical Hierarchy Process AHP, Amir Kabir Publications.2008. (In Persian).
16. Ahannejadreveshti M, Garakhlu M, Ziyari K. Modeling the structural vulnerability of cities against earthquakes using the Hierarchical Analysis Process method in the geographic information system environment(Case study: Zanjan). Journal of geography and development. 2010; 19: 178-186. (In Persian).
17. Rashed, K and weeks, J. Assessing vulnerability to earthquake hazards through spatial multicriteria analysis of urban areas, Interactional Journal of geographic Information Science 2003;Vol.17,no,6.
18. Naghsh Moheet engineering consultant. Master plan of Tabriz city. 2011. (In Persian).