

Analyzing Important Components that Increase Vulnerability to Natural Disasters

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Abstract

During the last three decades, the 4th district of Tehran has been facing an average annual population growth greater than the whole of Tehran and is considered one of the most populous areas. This region has significant diversity in terms of the economic, social, and cultural context of its residents. On the one hand, in this area, there are areas and neighborhoods such as Khaq Sefid and Shamiran No, which are considered to be the residences of the poorest and lowest-income social strata of Tehran. The regional crisis management plan, which was prepared in the form of crisis management of the whole city of Tehran, lacks a strategic and comprehensive approach on the one hand, and it is said to be different from other national, regional, and local plans (national and regional). In the crisis management plan of the city of Tehran, area 4 is considered as the relief and rescue area of the whole city. This weakness has also caused that in preparing the framework of the regional crisis management plan, both in terms of headquarters planning and organizational-executive dimensions and social, economic, and environmental factors in the current situation of the region, which happens to be one of the main causes of aggravation or increase. They are considered to be the cause of the region's vulnerability to possible earthquakes, they have not been taken into account. In other words, planning for crisis management in the region must be consistent with other physical-physical, social-economic, and environmental planning.

Keywords: Crisis, Crisis Management, Earthquake, Tehran's Region 4.

Introduction

Earthquakes as a natural phenomenon by itself does not have adverse results. What makes this phenomenon a disaster is the failure to prevent its effects and the lack of preparation to deal with its consequences.

Earthquake risks are classified into 4 categories and groups:

- Shaking and shaking of the ground.
- Fracture and displacement of the earth.
- Tsunami.

Secondary risks (including avalanches, mudflows and landslides, different land settlements and soil melting, floods caused by breaking dams and fences, and fires) (Sadigh Sarabi, M., et al., 2024. -b).

Any city or developed urban area may be threatened by these hazards, casualties caused by recent earthquakes have been high in urban areas. The 1976 Tangshan earthquake in China killed 250,000 people; the 1990 earthquake in Rudbar, Iran killed 40 thousand people; the 1991 earthquake in Spitak, Armenia killed 25,000 people, and the 1382 earthquake in Bam killed nearly 35,000 people. The rapid growth of the world's cities makes such crises more painful and frequent. It has been established that the results and consequences of natural hazards, especially earthquakes, are

increasing in urban areas. Planners put a lot of emphasis on the vulnerability of cities in development planning (Dehghan S. et al., 2024).

In cities, due to the high concentration of population, activities, capital, and the location of many infrastructure and construction facilities, the occurrence of one natural disaster, especially an earthquake, will show more loss of life and money (Kahvand, M., et al., 2015). Since the beginning of creation, controlling nature and overcoming harmful forces have been the main essence of human effort and struggle for survival and continuation of life (Karimimansoob, V. et al., 2024- c). This is even though, unlike the damaging natural forces with a continuous and at the same time predictable effect, human confrontation with natural forces and non-continuous and unpredictable accidents such as earthquakes is only focused on after their occurrence when there is a lot of his existence (Norouzian, M. M., & Sarabi, 2023).

During the last three decades, the 4th region of Tehran has been facing an average annual population growth greater than the whole of Tehran and is considered one of the population-capable regions. In terms of economic, social, and cultural context, this region has a significant diversity of its residents (Sadigh Sarabi, M., et al., 2024. -a). On the one hand, in this region, there are areas and neighborhoods such as Khaq Sefid and Shamiran No, which are considered to be the residences of the poorest and lowest-income social strata of Tehran. In these neighborhoods, the density of residential units, the small and interwoven structure of residential spaces, low literacy, and illiteracy, the size of the household is larger than the region and city, and the density of people in each residential unit can be seen (Norouzian, M. M., 2024).

On the other hand, neighborhoods and areas such as Pasdaran and Tehranpars can be seen along with the aforementioned neighborhoods, whose residents benefit from the opposite of the previous indicators, i.e. favorable urban space, large houses, Basaman crossings, high per capita income, etc. Examining the amount of damages and injuries is directly and indirectly related to the unfavorable state of urban planning and design (Maleki, M., et al., 2024). The bad state of establishment of physical elements and inappropriate urban uses, the inefficient communication network of the city, compact and worn-out urban fabric, high urban density, the bad state of establishment of city infrastructure, and the lack and inappropriate distribution of urban open spaces play a major role in the amount of damage to the city (Sohrabi, S. A., 2024).

Theoretical

Natural disasters. Natural disasters are disasters that occur due to the abnormal disorder of the main elements of earth, air, fire, and water, and the sufferings caused by this situation are as severe as in the past and are still being repeated (Gheitarany, N., et al., 2013- b). Such disasters include landslides, soil erosion, mudslides, tornadoes, hurricanes, volcanoes, earthquakes, etc. Natural disasters are acts of nature with such intensity that they create a catastrophic situation, and in this situation, the routine of daily life is suddenly interrupted, and people suffer and become helpless, and as a result, lack food, clothing, shelter, and medical care, nursing, and protection. Against unfavorable factors and conditions, they become needy (Gheitarani, N., et al., 2013- a).

In any case, an accident scene can be depicted with a broken body, suffering, and injured people, psychologically broken, bewildered, and worried managers, and a dysfunctional society (Norouzian M. M., et al., 2024). But the important point is that, fortunately, this image is not stable and permanent and is transitory. Disasters have characteristics that due to their occurrence in different areas, both urban and rural, it is necessary to clarify its aspects (Farrokhirad & Gheitarani, 2024).

The occurrence of such incidents in nature will not have direct and destructive effects on human lives as long as they occur far from human settlements (Naghibi Irvani, S., et al., 2024 -b). But throughout history, humans have always been faced with the occurrence of the aforementioned phenomena, which are caused by the action and confrontation of the elements of nature, near or at the place of their residences, so that the occurrence of natural disasters has often left destructive effects on human settlements. It has caused heavy losses to their residents (Sadigh Sarabi, M., et al., 2024. -c).

Because cities have different foundations and characteristics from other human settlements, if the comprehensive principles that require the establishment of the city in a specific place are neglected, they can be potentially dangerous living spots for causing crises in the event of natural disasters. Cities have a body, each of these bodies has an activity in it, and all of them make up the urban space and give it an identity (MM Norouzian & N Gheitarani, 2023).

Crisis. Any event that endangers human life and property in a way that requires immediate and emergency action is called a crisis. It is necessary to clarify that according to the scientific texts related to crisis management, we find that the word emergency is generally applied to all incidents and crises (Aghazadeh, M. et al., 2017). However, by carefully observing the scientific texts related to crisis management, it seems that the word Disaster (meaning natural disaster) is used when we mean natural accidents and crises, and the word Crisis is equivalent to man-made or natural accidents and crises. Every incident has the potential to turn into a crisis if it is not properly controlled (Norouzian & Sarabi, 2023).

Emergency conditions. It refers to all situations that are outside the normal conditions and routine of life. Emergency conditions have different levels, which will be mentioned in detail in the continuation of crisis management discussions (Gheitarani, N., et al., 2024- c).

Sustainability. The stability of the capacity of a system or system, society, or community is potentially facing risks to adapt through resistance and standing or to create changes to continue and achieve an acceptable level of performance and structure (Dehghan S. et al., 2024). This point is measured and recognized through the extent and degree to which the social system can organize itself to increase its capacity to learn from past crises for better protection in the future and to improve risk reduction measures (Aghazadeh, M. et al., 2019).

Capacity. The resources at the disposal of unique individuals, households, communities, local communities, institutions, organizations, and nations to resist the effects of a hazard are called capacity (Norouzian & Gheitarani, 2024).

Vulnerability. Vulnerability is defined as the conditions defined by physical, social, economic, and environmental factors and processes that increase the sensitivity and fragility of society against risks (Gheitarani, N., et al., 2020). What we mean by vulnerability is the internal conditions and situations that increase people's exposure and sensitivity, susceptibility, and fragility to risks or other shocks and pressures. Vulnerability is something beyond the possibility of building collapse and damage to infrastructure. Conventionally, vulnerability is a way to conceptualize what may happen to a specific population under certain risk and hazard conditions (Khanian, M., et al., 2019).

Vulnerability is the conditions determined by physical, social, economic, and environmental factors or processes that increase the vulnerability of a society to the pressure of risks, these factors and processes are:

- Demographic factors such as population growth, urbanization, settlements near coastal areas, etc.
- An increase in tangible assets leads to an increase in losses.

- The state of economic development: poverty, modernization processes
- Political factors; climate changes, degradation, and depletion of resources;
- The effects of crisis protection structures and research and the mutual effect of different causes of crises (Sadigh Sarabi, M., et al., 2023- a).

Methodology

Scientific researches are divided into basic, applied, and practical research based on the purpose. According to its purpose, the current research is applied research. In terms of application, this research has been used for related government and private organizations, such as the regional municipality, the crisis management headquarters of Tehran, the Red Crescent population organization, and the consulting engineers of Tehran and the region, as well as for conducting supplementary research by university students, and it has been of particular importance (Karimimansoob et al., 2024- b).

In this research, firstly, an attempt was made to collect the theoretical bases, frameworks, and fields of studies that have been conducted in connection with the subject of earthquakes and urban crisis management in Iran and the world (Ghadarjani et al., 2013- a). And then, based on them, the problem has been determined and checked, and the selected area has been researched and analyzed. In terms of its nature and method, the current research is applied descriptive research, the results of which can be used in decision-making, policy-making, and urban planning (Dizaji, A. et al., 2023).

In other words, in this research, an attempt is made to explain the relationship between urban planning criteria and effective factors in reducing or increasing earthquake damage (Zaker Haghighi et al., 2014). Therefore, in this research, qualitative and quantitative variables have been selected by first extracting urban planning criteria related to earthquakes from existing studies and document sources (Karimimansoob et al., 2024- a). Then, by examining the physical, socio-economic, environmental, and management conditions in the current state of the study area, the action or reaction of the studied variables is analyzed and the probability of earthquake vulnerability is estimated about these variables (Gheitarani, N., et al., 2024- a).

Data collection. Also, by collecting the available information and texts for the current situation of the 4th district of Tehran, various organizations and bodies were referred to where updated information and statistics could be found (Naghbi Iravani, S., et al., 2024 -c). As an example of information and statistics related to population and households, economic information on households and the housing and construction sector was obtained through the Iran Statistics Center. Also, the database files of the studied region were obtained in the form of geographic information system software, which was prepared and compiled by the vice-president of urban planning of the 4th district of Tehran and with the cooperation of field consulting engineers.

Analysis of information. In this research, multi-criteria evaluation methods have been used to analyze the findings. In this type of method, it is possible to analyze and present all the information available in the options, based on different and multi-dimensional criteria (Sadigh Sarabi, M., et al., 2024. -d). These evaluation methods may be completely quantitative, such as the matrix method of achieving goals, or they may be completely qualitative, such as the system analysis method, or a combination of qualitative and quantitative information, such as the environmental impact analysis methods and the hierarchical analysis process method, which is the last method used in this research (Aghazadeh, M. et al., 2018).

District 4. Out of the total population of 76,924 people living in District 4, 53.6% are men and 46.4% are women. Nevertheless, the sex ratio in this area is equal to 115.5, in other words, for

every 100 women, 115 men live in this area, which does not seem like a balanced ratio. On the other hand, 31.3% of the total population living in the district are in the age group of 0-14 years, and 55.4% and 13.2% are in the age groups of 15-64 and above 65 years, respectively. In this way, the number of people in the age group of 0-14 years is slightly more than the average in other areas (Naghbi Iravani, S., et al., 2024 -a).

Results

Eshraq Station Eshraq metro station is located in the vicinity of Eshraq Cultural Center. This 2.5 km long station is one of the most important and crowded subway stations in the east of Tehran, and in addition to providing easy access to Farhangsarai Eshraq, it provides the possibility of using the subway and access to different areas of the city for the residents of the easternmost neighborhoods of the region. This station also provides access to the metro network for residents of Javadiyeh, Tehranpars, and Hakimiyeh neighborhoods, which are among the most populated neighborhoods in eastern Tehran. Every day more than fifty thousand passengers travel by metro through this station.

Table 1. Transportation and traffic situation in District 4 of Tehran

Number	Type of road network	Status
km26/52	First-class artery	The state of the road network
km23/26	Class II artery	
km25/32	Highways	
km22/402	Collector and access to passages	
287	The number of bus fleets	The state of transportation and public facilities
2	number of terminals (taxi)	
7454	The number of red and white line taxis	
36	Number of bus lines (originating and transiting)	
116	The number of taxi lines (originating and transiting)	
303	Number of bus stops	
1	Metro lines passing through the area	
5	Number of subway stations	
1	Floor parking available	The condition of the parking lots
400	Floor parking capacity	
6	Mechanized and level parking	

Examining the current situation of land use in Area 4 shows that in this area the predominant uses are residential, higher education (Iran University of Science and Technology is located in this area), educational, commercial, and to some extent green space use. Such a way that residential use with 57.9 percent (not considering residential mixed-use), higher education use with 17.5 percent, educational use with 3.3 percent, industrial-workshop use with 2.9 percent, green space with 4 2.2% and commercial use with 2.2% have respectively allocated the highest levels of the district's land. Therefore, these figures show that the diversity and multiplicity of types of uses are evident in this area and this can cause the mixing of uses in terms of functionality or compatibility.

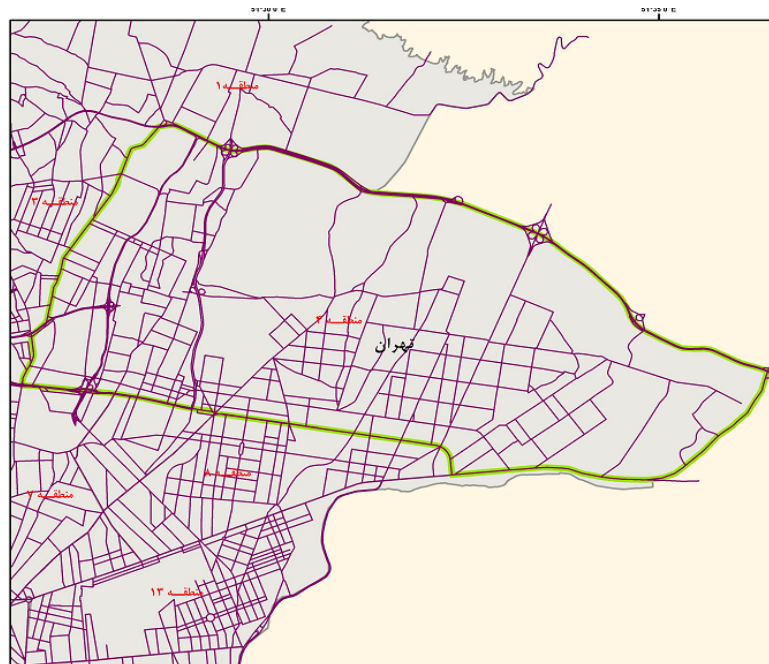


Figure 1. The location of communication networks in area 4



Figure 2. Urban land use distribution in area 4

What emerges from the studies of the current situation of the region is that, in terms of topographical conditions, the 4th region of Tehran is located on the southern slopes of the Alborz mountain range and covers the north-northeastern limit of Tehran metropolis. This area leads to many heights and many natural effects are evident in it. From a social and economic point of view, it can be said that different strata and classes live there and a considerable socio-economic difference can be seen among the residents of the region.

Investigating the current situation of residents in terms of various social indicators such as population distribution in areas, age and gender composition of the population, percentage of literacy, percentage of illiteracy, and economic indicators such as the amount of active population, population over 10 years old, percentage of employment and unemployment, etc. Many limits show these differences.

Tehran crisis management. The purpose of crisis management in Tehran is to adopt policies, plans, designs, create the necessary preparation for citizens and accurately determine the scope of responsibility and authority of executive bodies of urban management, organize and integrate all the elements and factors involved in crisis management (Sadigh Sarabi, M., et al., 2023- b). Using all the national, provincial, and regional facilities and people's forces, directing all government and non-government, domestic and foreign aid to prevent and reduce the effects of unexpected accidents, providing quick and optimal rescue services. And relief, reducing human and economic losses and restoring living conditions to normal.

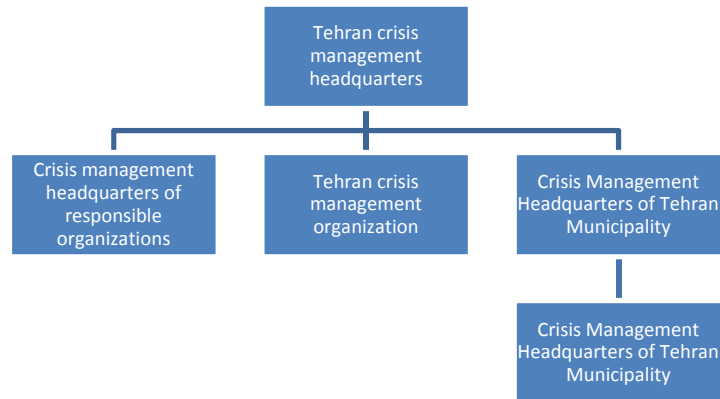


Figure 3. Crisis management structure of Tehran city in normal conditions

Studies of the International Institute of Seismology and Earthquake Engineering and Geological Organization. To understand the seismic situation of Tehran, the seismic potential of the main faults in a radius of 150 kilometers from the center of Tehran has been studied. These studies have been evaluated in cooperation with the Geological Organization of the country and the Japan International Cooperation Agency, and the final summary has been presented in the form of the accelerated distribution of rocks in Tehran (Gheitarani, N., et al., 2024- b). The surface fault potential in Tehran has also been studied in parallel with risk estimation studies. The information shows that in addition to the main faults in the city limits of Tehran (North of Tehran, North and South of Ray), numerous faults with smaller dimensions are also scattered throughout the city.

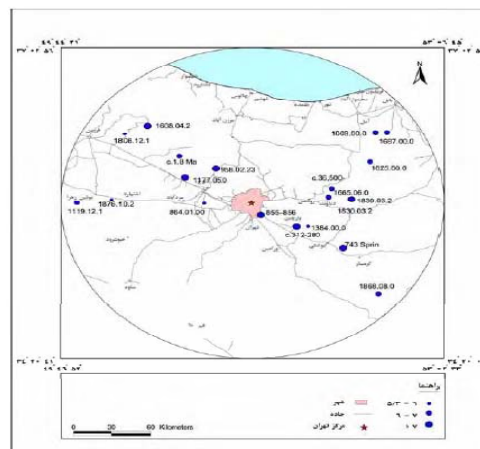


Figure 4. The epicenter and magnitude of historical earthquakes in Tehran area

Studies of the Japan International Cooperation Agency (JICA). The final assessment of the JICA study group to assess the amount of damage caused by the activated North Tehran fault shows that in the case of the North Tehran fault model, the northern part of the city is facing a lot of seismic risks and damages. Because the fault is located on the northern edge of the city. In general, the crisis has smaller dimensions compared to the Ray fault model (Norouziyan & Gheitarani, 2023).

Because the land conditions and social conditions in the northern parts of Tehran are better than its southern areas. In this model, the earthquake risks and damages are high in the northern part and the riskiness of social conditions is high in the southern part (Zakerhaghighi et al., 2015). But none of the areas have extraordinary vulnerability. It should be noted that the damage to residential houses in areas 2, 3, and 12 is relatively large. In addition, there will be relatively less damage in the southern part. However, there may be many issues and problems due to the lack of open space for evacuation and the lack of temporary evacuation houses (Ghadarjani et al., 2013- b).

Table 2. Land use of the region according to the type of compatibility

Percentage	Area - hectares	Compatibility of applications
02/84	85/5145	Fully compatible
9/6	44/425	Relatively compatible
11/4	8/251	Indifferent
06/3	4/187	Relatively inconsistent
8/1	6/112	Completely inconsistent
100	9/6123	Total area

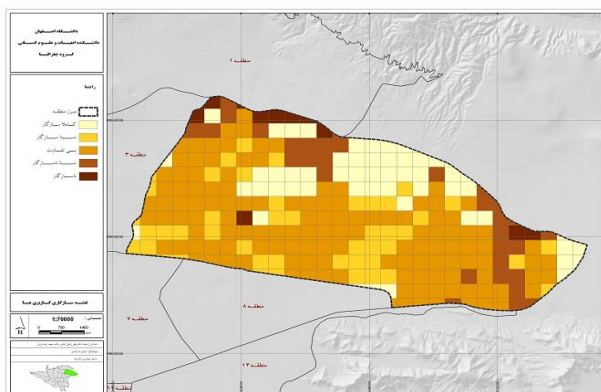


Figure 5. Distribution of compatibility of uses in the 4th district of Tehran

Results

Table (3). The results obtained from the AHP method show the degree of vulnerability of area 4 in different spectrums. To confirm or reject the first hypothesis, we must first know whether there is a correlation between the values of the neighborhood weights of the uses for different vulnerability options with the final weight of each of the options and then with the population values and the extent of vulnerable areas or not. Is this correlation a positive correlation or not, and if there is a correlation, what is its scope? In other words, how much does the neighborhood variable of urban structures explain the vulnerability of the region? To find the answer to these questions, the neighborhood weight variable has been compared with each of the independent variables of population and vulnerable size and the final weight variable of each of the options.

Table 3. The degree of vulnerability of the regions in terms of weight, population, and area

Percentage	Percentage	Vulnerability	Neighborhood privilege	Vulnerability
01/23	05/16	0.084	0.034	Low risk
4/29	16/40	0.090	0.032	Moderate risk
4/19	6/29	128/0/0	0.096	High risk
3/17	08/14	0.260	0.047	Very high risk
100	100	0.562	0.101	The whole area

The relationship between user proximity and population vulnerability. The correlation coefficient between the proximity of uses and the vulnerable population is equal to 0.176 and the range of changes between the proximity of structures and the vulnerable population is equal to 0.031, which shows a lower figure compared to the previous index. Therefore, according to the above, the dependence (scope of changes) and correlation between the variables of the neighborhood of uses and the total vulnerability are evaluated very high, and after that, the dependence of the neighborhood variable with the variable of the extent of vulnerability is higher.

These figures show that, firstly, the neighborhood of urban structures will play a greater role in the overall vulnerability of the region, and secondly, the vulnerability caused by not observing compatibility in the neighborhood of uses will have a lot to do with destruction and vulnerability in the hectare module. In other words, the lack of compatibility of users with each other will lead to an increase in the extent of vulnerability and destruction caused by it.

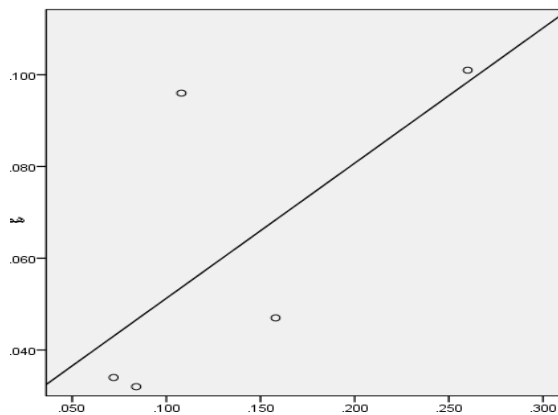


Figure 6. Two-way linear regression between neighborhood variables and overall vulnerability

Table 4. Correlation between vulnerability variables

Extent of vulnerability	Population vulnerability	Total vulnerability score	User adjacency	
0.423	0.176	0.666	1	User adjacency

Conclusion

Evaluation and decision-making to measure the level of vulnerability caused by an earthquake by considering different aspects based on one or more low-impact factors is not effective and it is necessary to consider a set of factors, considering the importance of each of them. The goal of

strategic planning is to improve the quality of life in Region 4 by improving economic, social, environmental, and physical conditions; in such a way that this area becomes a safe area against earthquakes and the amount of human casualties caused by earthquakes in it is reduced to the minimum possible. Strategies are the decisions that coordinate the macro goals, follow the ideal conditions of the system to be intervened, and clarify the general direction of action and action to achieve the goals. Policies are also the implementation interpretation of goals; this means that policies are decisions that are taken to implement strategies and reach implementation areas.

- Creation and promotion of open and collective spaces
- Organization and optimal management of fire stations and temporary accommodation places
- Reducing building density and balanced redistribution of population in the region
- Organization, provision, and optimal reconstruction of urban infrastructures

Based on the studies of the Tehran Crisis Prevention and Management Center and the Iranian Red Crescent Society, a list of safe evacuation spaces available in the region, which have the possibility of temporary accommodation in an emergency, has been prepared. So about 1134 hectares of the region's lands, including the parks and open spaces of Louisan, Pardis, Narun Park, and Javaherian Garden in Louisan, are among the spaces that are available as safe evacuation spaces in the region and can be used (Khanian, M., et al., 2013). In the municipal limits of Region 4, the total area of the evacuation places and spaces expected for emergency accommodation is about 3033527 square meters, of which 2930007 square meters are considered habitable soldier spaces and about 103520 square meters are part of the limited shelters that can be accommodated. All the planned spaces in the region accommodate a population of 116,492 people in the form of 227 places, which is about 15% of the total population of the region.

Table 5. List of regional safe evacuation spaces available in District 4 of Tehran

Area - hectare	Spaces	Row	Area
5.8	South-eastern Park, the intersection of Lashgark and Ezgol streets	1	Area
6.5	Javaherian Garden in Louisan	2	
334.2	Louisan Park	3	
431.8	Narun Park on Babai Highway	4	
188.5	Campus Park	5	
135.2	National Forest Park on Babai Highway	6	
32	Park and open space south of Hakimiya	7	
1134	total sum	8	

Table 6. List of safe evacuation places and spaces expected in Region 4

Number of people	Can be accommodated (number of people)	Accommodation (square meters)	Number
18824	Indoor habitable	2930007	Deployable soldier
97671	Can accommodate soldiers	103520	Covered and habitable
116492	Fully habitable	3033527	total area
Total number of places: 227			

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