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Spatial distribution of absorbing centers of population with seismic structure in Kerman City

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Abstract
Iran is located in an area with high earthquake risk. There are over 20 active faults with length of 500 km and also densely populated parts of the country have been rendered vulnerable to strong earthquakes. However, existence of eight faults of the main faults of Iran along with at least 18 faults with length of more than 100 km in Kerman province have turned the place into one of the riskiest areas of the country. For this reason, this research tries spatial distribution of absorbing centers in Kerman population compared to the high risk of seismic zones of the city. The results show that the total population of absorbing centers in Kerman is 22.2% of the training centers, 34.5% of health care centers, 22.2% of administrative centers, 14% of business centers, and 18.9 % of sports centers which are located across the threat of severe and very severe degradation. In other words, among 973 absorbing centers of population, 190 centers in Kerman are located in zones with high and very high damage and 206 centers are in areas with moderate damage; this means that among total centers of absorbing centers, 396 centers are located in zones with moderate to high risks. The importance of these centers, as well as aggregation of population in these centers, in urban spatial structure and prediction of approaches such as resisting, retrofitting of public education and crisis management is in reducing losses in the event of a seismic event that seems very likely.

Keywords
faults, Iran, Kerman, population centers, seismicity.

1. Introduction
Our country has experienced many destructive earthquakes due to being located between the Alpine-Himalayan seismic belts and we must take into account the fact that 66 percent of our country is located in earthquake-prone areas and 90 percent of the population is living in these areas. This is while the cities of our country are extremely vulnerable against earthquakes with magnitudes of 5.5 to 6 Richter (Qhaedrhmati et al., 2013: 2). Excessive increase in population, urban constructions, and its expansion to the suburban areas, without proper planning and consideration of arrangement and laws, has worsened the condition. Accordingly, locating suitable settlements and logical and principle urban development have a fundamental role in reducing vulnerability and damages caused by the earthquake (Nateghi, 2000: 205).

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On this basis and according to the importance of the issue, many studies have been conducted on the subject, including Nasiri (2016), who conducted a research of zoning earthquake hazard of the urban area of Urmia province and found that the acceleration of 0.035 to 0.33 g reflects the high seismicity in the study area.

In another study, Esfandiari et al. (2014) assessed if the earthquakes could cause faults and loss of life in the city of Ardabil and suggested that an earthquake at night, without any relief, would cause severe losses. He estimated that 74,945 residents, or about 17.5 percent of the total population of Ardabil, would be killed.

Also, Hassanzadeh et al. (2011) analyzed Kerman seismic using GIS and suggested that fifteen pieces of faults have the ability to build an acceleration over 0.2 g in the city of Kerman. Accordingly, the amount of risk in the central, western, and southern parts of the city greatly increases such that structures in these sectors will be severely devastated by the earthquake potential.

Panahi et al. (2014) also analyzed the seismic vulnerability assessment of school buildings in Tehran based on AHP and GIS techniques and suggested that in 72 (about 3%) out of 2125 school buildings of the study area the destruction rate would be very high and, therefore, their reconstruction should be seriously considered.

In another study, Lantada et al. (2009), while modeling vulnerable areas in Barcelona in relation to seismic hazards using VIM[1] and CSBM[2], concluded that the city is in the range of low to medium risk in terms of vulnerability. These two methods have sufficient credibility and analysis power in estimating earthquake risk.

Kerman is located in one of the most active tectonic seismic areas of Iran and there are several active faults near the city. From the minimum of 20 great faults of over 500 km identified in Iran, eight faults are in vast Kerman Province. There are also at least 18 faults with over one hundred kilometers in the province which are all active in the Quaternary geology and make Kerman a moving and earthquake-prone area. Kuhbanan faults with a length of 300 km in the north of Kerman, Lakarkoh with a length of 130 km in the north of Kerman, Nayband with a length of 400 km, Raver with a length of 130 km, Gook (Golbaf) with a length of about 100 km extended from South West of Bam to West of Shahdad, are the most important faults (Yaghmaei and Noroozian, 1993, 110).

Figure 1 shows the position of important faults in the province. Performance of these faults since 150 years ago has created several earthquakes in the province. As in the past 15 years, in average, we have witnessed 6 killed and four injured every day in the earthquakes of Kerman (Table 1). Accordingly, the earthquake risk analysis using probabilistic method indicates the probability of earthquake with 7 Richter during every 10 years over the area in a radius of 300 of Kerman (Hosseini et al., 2014: 150).

Several factors such as almost worn out urban fabric, non-compliance with the required standards of construction, unstable ground, and, most importantly, lack of proper distribution of population structures in relation to fault structure are effective in causing disproportionate damage in earthquake. Centers with absorbing population such as commercial, educational, sanitary-therapeutic, and sports are important for the performance of space systems.

It also covers the major centers of population - socioeconomic, educational, and other human activities-through the aggregation of multiple components; they will always be vulnerable to a collection. After maintaining stability and security, especially against natural disasters such as earthquakes, particular importance in organizing urban spaces is optimal. Therefore, to avoid the concentration of absorbing centers of population and lack of diverse socioeconomic, educational, health, and sports clubs in high-risk and low-risk areas, preparing and designing map of spatial distribution of absorbing centers for population and other activities should be aimed to reduce the vulnerability in seismic zone. For this reason, this research tries spatial distribution of absorbing centers in Kerman population compared to the high risk seismic zones and the city planning principles in dealing with the study of seismic events.

1. vulnerability index method
2. capacity spectrum based method

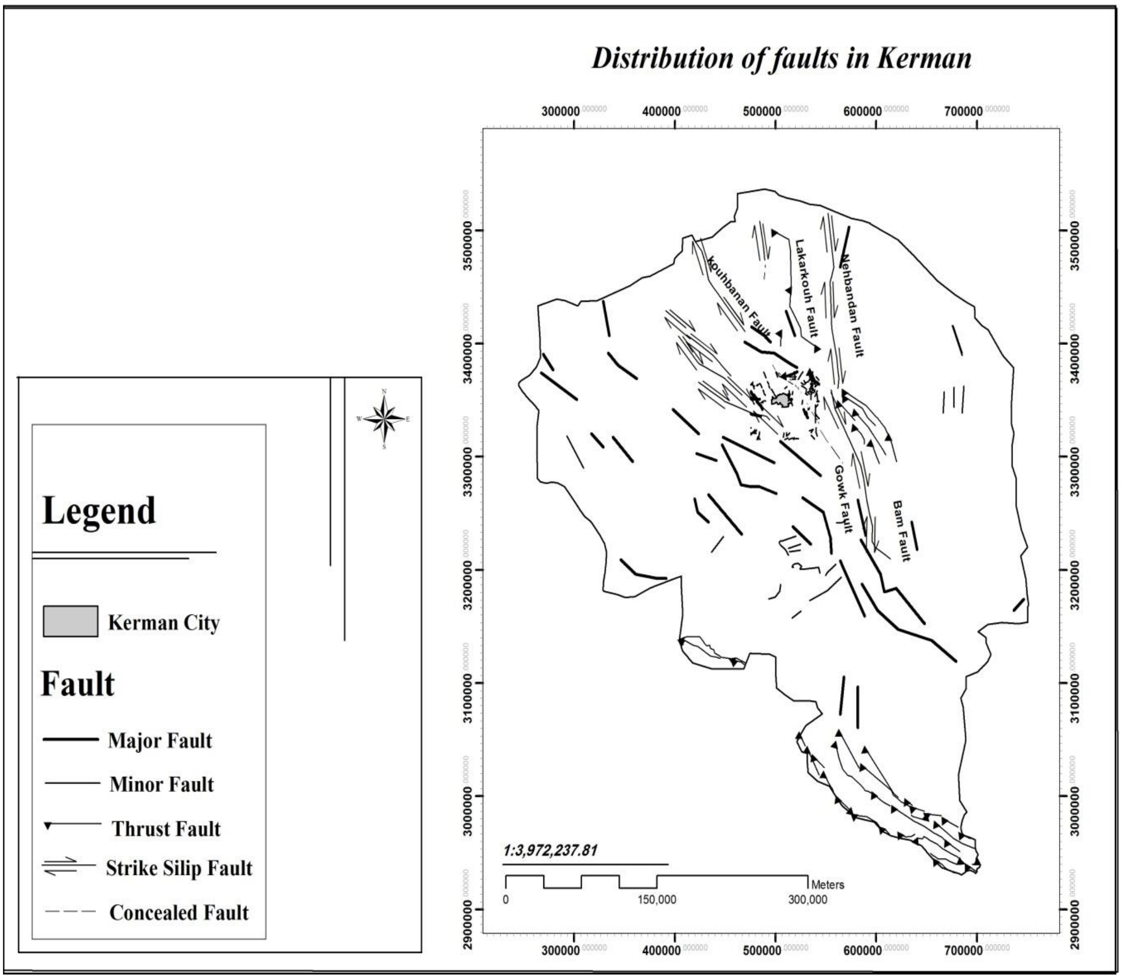

Fig. 1. Distribution of faults in Kerman

Table 1. Earthquakes occured in Kerman

Place of occurrence	Damages	Date of occurrence	Severity of the earthquake
Harjand	Deaths and the destruction of the green dome of Jame Mozafar Porch in Kerman	1864	....
Chatrood		963 January	
Chatrood	Damage to buildings	1881 July	....
Koohban	Damage to buildings and drying springs	1885	....
Siraj	…..	1886	....
Koohban	…..	874 January	....
Chatrood	Sarasiab village destroyed, damaged and destroying buildings in Kerman Nazareth garden and full destroy of green cupola dome in Kerman	1897 June	....
Jooshan	…..	1919 November	....
Ravar	700 killed and completely destroyed all the houses and countryside in Ravar	March1921	....
Lalehzar	200 killed and destroying Goghr village and Khatib villages, Asgar castles and lalezar, damage of Vakil tower in Kerman	September August January 1923	....
Negra and Bardsir	……	1953 July	....
Golbaf	Leaving Financial damages	June 1938	6 Richter
Siraj	…..	1938 August	....
Siraj	665 killed and 260 wounded, and the complete destruction of the village Gisak	1977 December	

Table 1. Earthquakes occured in Kerman

Place of occurrence	Damages	Date of occurrence	Severity of the earthquake
Golbaf	1071 killed and 4000 injured	1981 June	6.8 Richter
Siraj	1300 killed, 915 injured, and 25,000 homeless, destroyed whole villages and 85% of homes in the affected part of the market but in Mahan, Kerman, and part of the tomb of King Nematullo Vali in Mahan	1981 July	7.1 Richter
Golbaf	40 people were killed and 45 people injured	1989 November	
Golbaf	Leaving 3 killed	2007 May	6.9 Richter
Shahdad	Leaving Financial damages	2008 November	5.6 Richter
Golbaf	Leaving Financial damages	2008 January	5.1 Richter
Bam	33 thousand and 489 killed and 500 people were killed and 17 injured SCI 248, 108 amputations, 41 deaf and 56 blind as well as the complete destruction of 24,283 urban housing, rural housing 10,145 3126 business	2009 January	6.5 Richter
Zarand	657 killed, 1,411 injured and 12,449 houses completely destroyed	2009 May	5.5 Richter
Mohammadabad Rigan	Five killed	2010 December	6.3 Richter
Siraj Koohpayeh	….	2012	5.5 Richter

2. Study area

Kerman province is located in the South East of Iran in the south of provinces of Yazd and Khorasan, north of the province of Sistan and Baluchestan (Zangiabadi, 1991: 21). Kerman is located in the North East region and in the range of more than 100 square kilometers (main plan of Kerman: 2000) at geographical position 56 degrees 55 minutes to 57 degrees, 15 minutes in east longitude and 30 degrees and 10 minutes in latitude 30° 20 minutes (Aftabi, 2006).

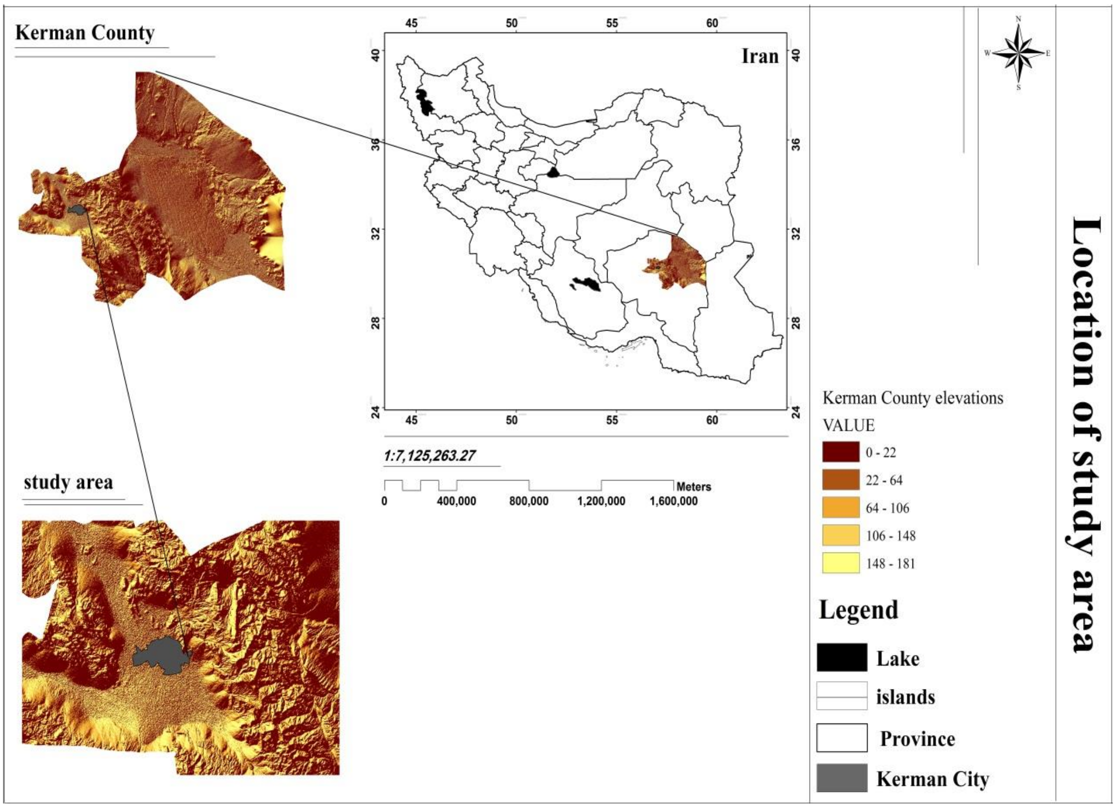

Fig. 2. Location of the study area

3. Materials and Methods

A descriptive-analytic and cross-sectional method using field data and libraries (documents and maps) is utilized to evaluate the theoretical foundations of the study area. Then, using geological maps and mapping of faults, fault map of the area is developed. Using data from the Housing and Urban Development, Municipal Center, and Kerman areas cad and jpg files and field studies of absorbing center population, such as commercial, sport, health, and education centers, identification and mapping of the spatial distribution of these centers were prepared. Then, using Zoning Map, degradation in Kerman (Abbas-Nejad and Hassanzadeh, 2006) and overlaps were drawn with final absorbing foci of population.

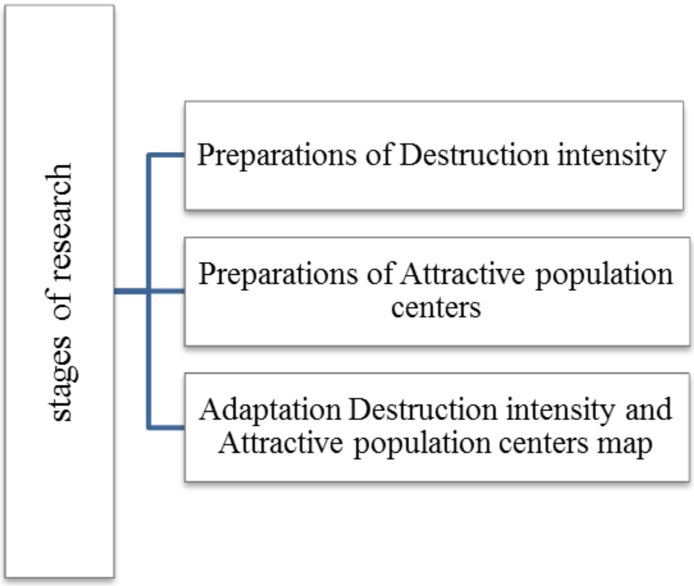

Fig. 3. Flowchart of the methodology stages

4. Research findings

The spatial distribution of population toward factors and trouble making fields are the basic principles of urban planning. Due to structural position and tectonic earthquake in Kerman that was noted, earthquake is the most probable hazard in the region. It should be noted that various factors such as slope, population density, building density, building age, and distance from open area have caused the increased vulnerability of residential in the face of the earthquake. In this regard, attractive population centers due to high population density at different times of the day are among the most vulnerable in urban centers.

In this regard, Figures 4 to 12 show Kerman population spatial distribution centers in zones with different degradation severity. Research findings indicate that these centers are mainly in central areas and worn fabric of the city is more vulnerable. For this reason, inappropriate spatial distribution of attractive centers in Kerman population has caused these centers to be mainly located in zones of moderate to severe intensity, which this factor drastically increases the vulnerability of these centers in the face of probable risks.

Ground motion can assess exacerbation of standard penetration tests (SPT) of land classification based on data from boreholes, geotechnical data, measurement of micro tremor wave or velocity of the soil absorption. Map of micro tremor and deposition of the sub-zone classification maps, level of motion intensity of land degradation, and the zoning map of Kerman in intense X MMI was created (Abbas-Nejad and Hassanzadeh, 2006) (Fig. 3).

The amount of data distribution with superstructure facilities after the earthquake destroyed much of the show in the fifth level. Table 2 shows distribution of number of educational centers in zones with different damage.

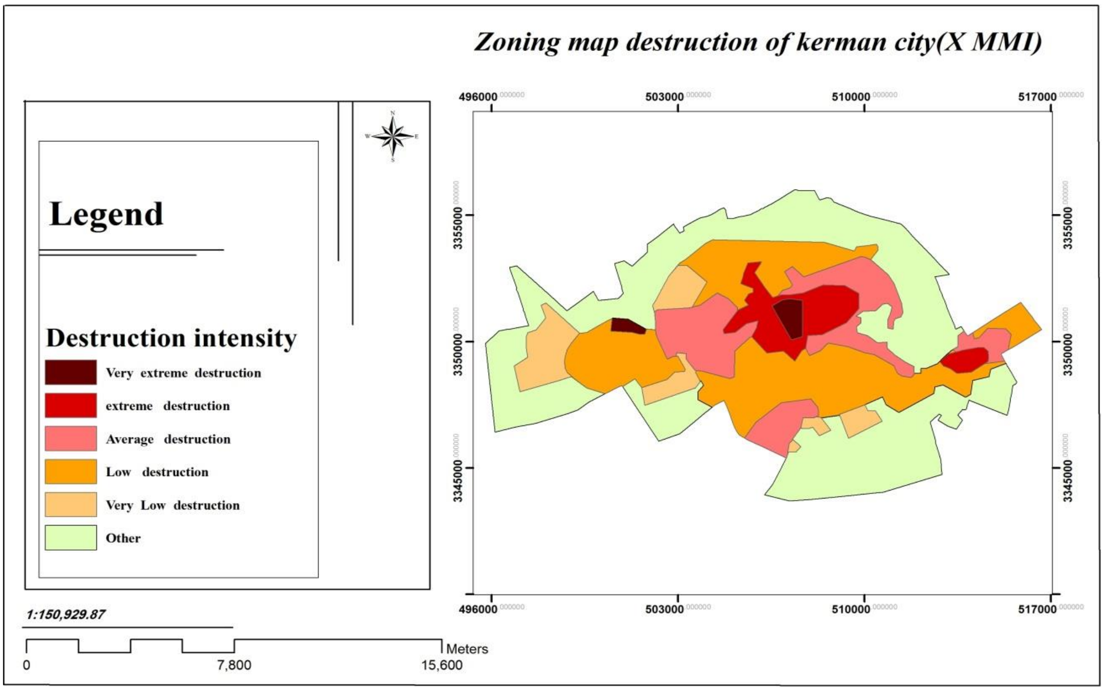

Fig. 4. Zoning map of Kerman degradation due to the earthquake intensity X MMI (Abbas-Nejad and Hassanzadeh, 2006)

Table 2. Level of distribution of educational centers due to destroy intense separation

Number of centers	Destruction intense
8	very intense
59	Extreme
82	Medium
127	Low
18	Very low

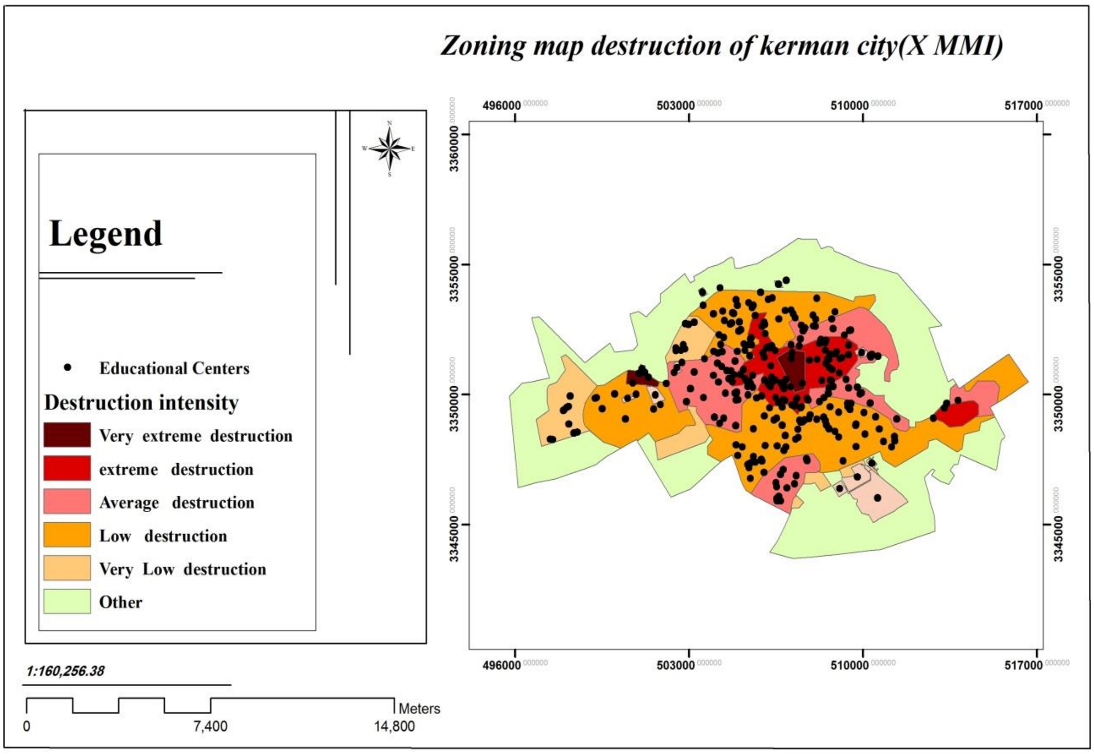

Fig. 5. Map of the distribution of educational centers due to separate destruction intense

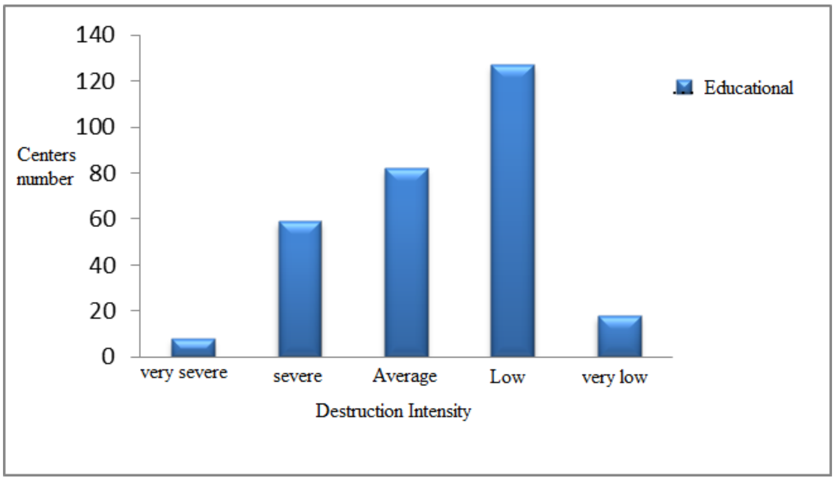

Fig. 6. Graphs of distribution of educational facilities due to separate destruction intense

Forms of distributed learning centers in zones 3 and 4 show the damage varieties. According to these forms, the largest number of educational centers, with 127 centers and 67 centers, are in the area of low level risk areas that are very sharp and intense. Distribution of care centers in different zones of damage is shown in Table 3.

Table 3. Table distribution level of sanitary-therapeutic centers to separate destruction intense

Number of Center	Destruction Intens
6	Very severe
23	Extreme
24	Medium
31	Low
0	Very low

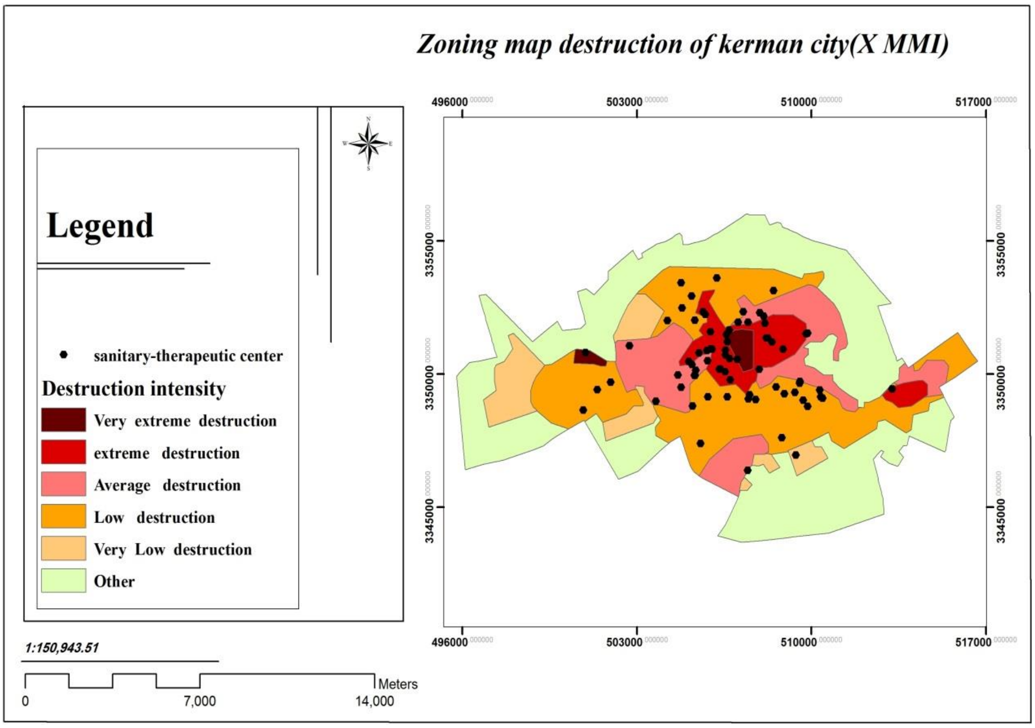

Fig. 7. Map of distribution of sanitary-therapeutic center due to destruction intense

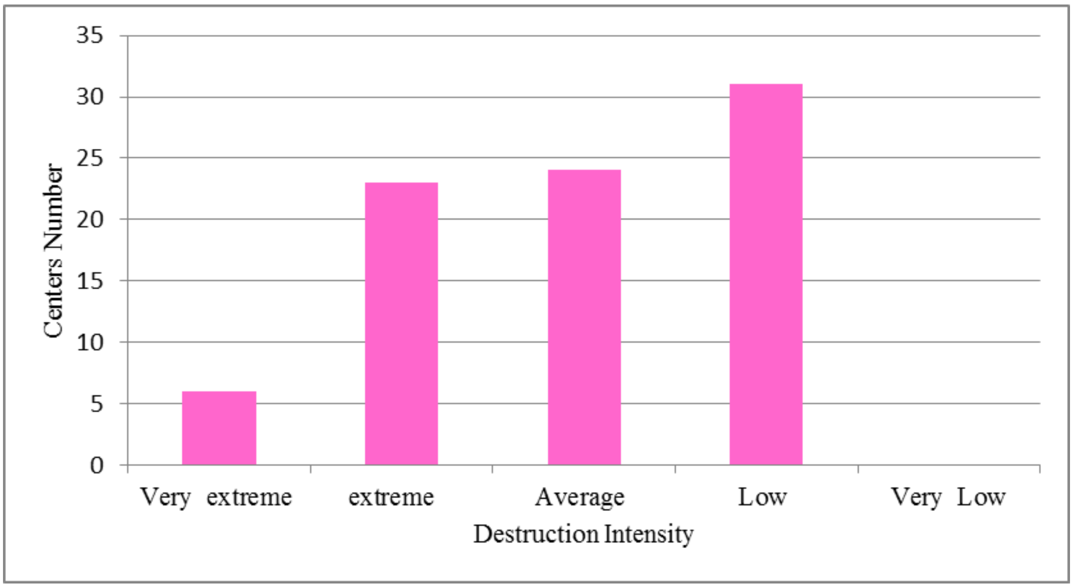

Fig. 8. Graphs the distribution amount sanitary-therapeutic center due to destruction intense

As shown in Figures 5 and 6, the highest number of care centers is 31 centers located in low level risk areas. 29 centers are located in zones with very severe damages in which 6 centers are located in the center of the area with the most severe damages. Distribution of administrative centers in different zones of damage is shown in Table 4.

Table 4. Distribution rates to administrative centers due to separate damage

Number of Center	Destruction Intense
8	Very severe
16	Extreme
25	Medium
54	Low
5	Very low

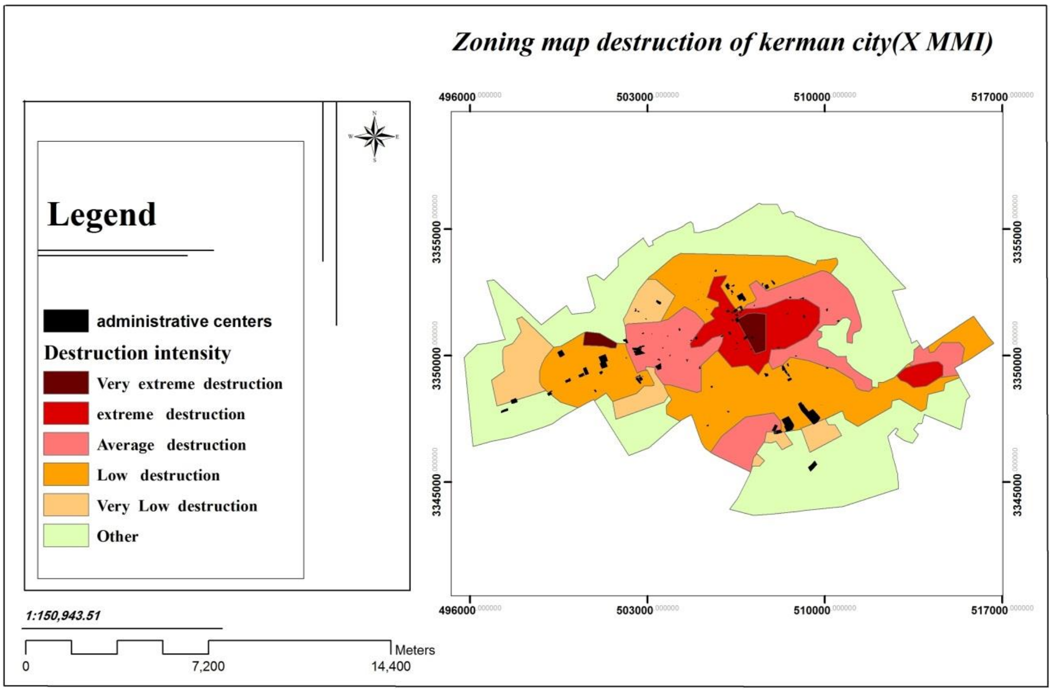

Fig. 9. Map of the distribution of administrative centers due to destruction intense

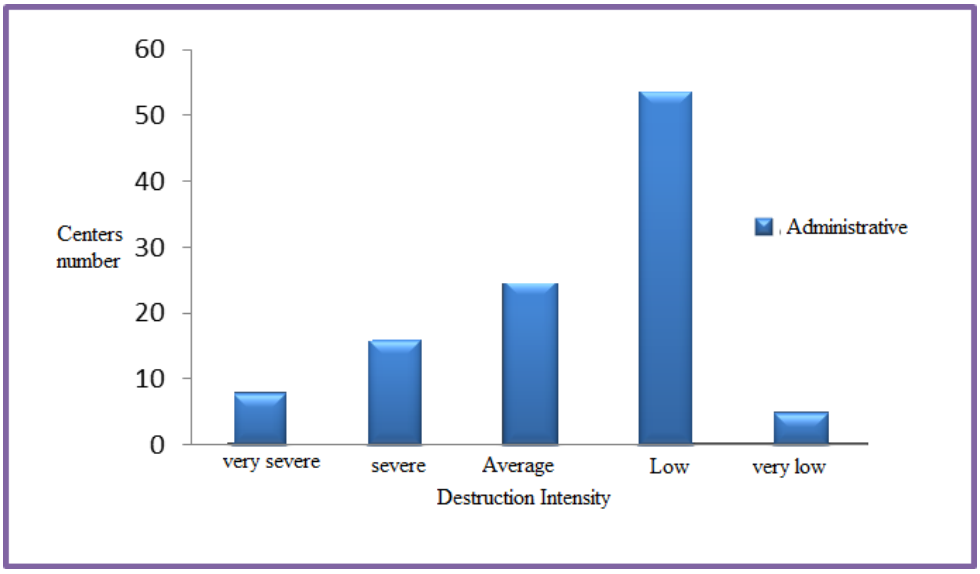

Fig. 10. Graph of distribution of administrative centers due to destruction intense

According to Figures 7 and 8 show the highest number of administrative centers from which 61 centers have very low levels of risk and low damage. 24 centers are located in zones with very severe and severe damage and 8 centers have been in zones with very severe damage. Table 5 indicates distribution of the number of malls in the area with different damages.

Table 5. Commercial centers distribution due to destruction intense

number of center	Destruction intense
16	Very severe
47	Extreme
64	Medium
283	Low
40	Very low

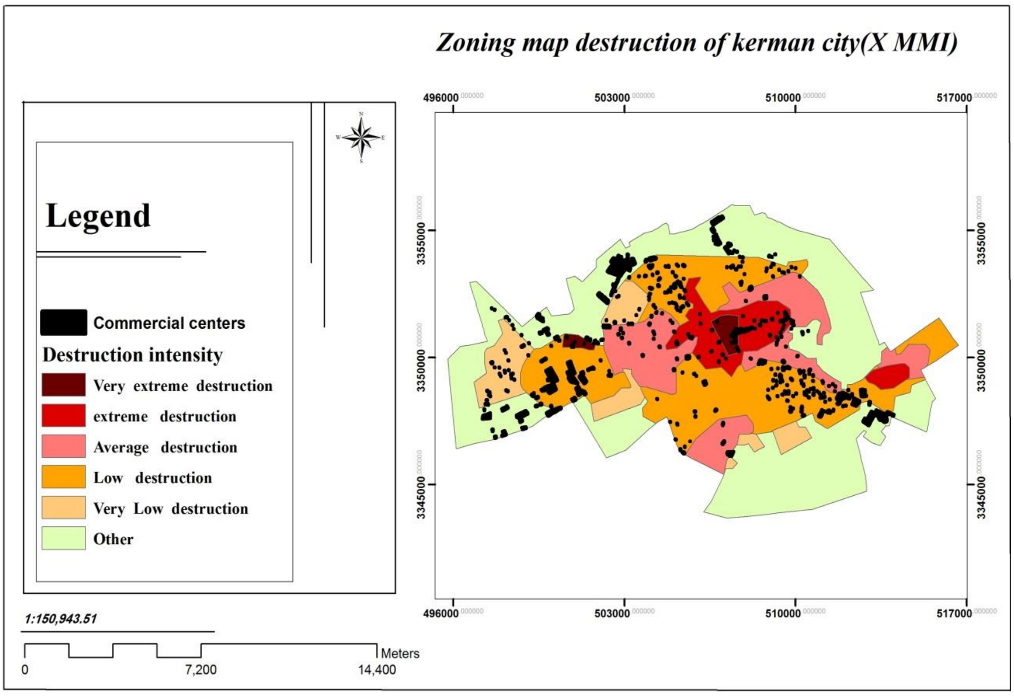

Fig. 11. Map of the distribution of Commercial centers due to destruction intense

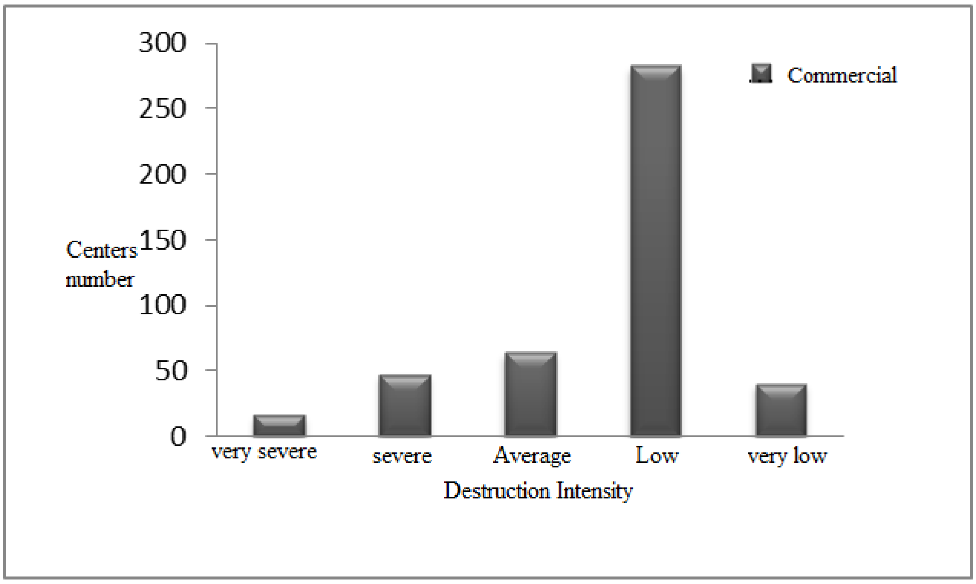

Fig. 12. Graph of distribution of Commercial centers due to destruction intense

According to Figures 9 and 10, the highest number of commercial centers, 323 centers have very low level of risk and low damage. 63 centers are located in zones with very severe and severe damage and 16 centers have been in zones with very severe damage. Distribution of sports centers in different zones of damage is shown in Table 6.

Table 6. Sports centers distribution due to destruction intense

Number of Center	Destruction Intense
1	Very severe
6	Extreme
11	Medium
14	Low
5	Very low

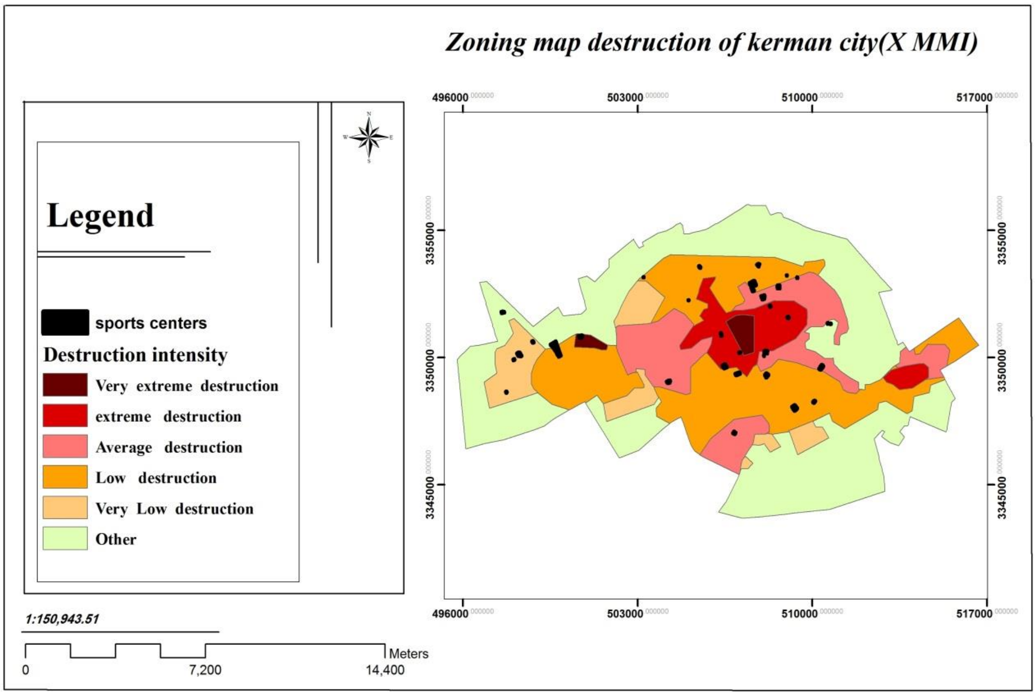

Fig. 13. Distribution of sports centers due to separate destruction intense

Fig. 14. Graph of distribution of sports centers due to destruction intense

According to Figures 11 and 12, the highest number of sports centers, 19 centers have very low level of risk and low damage. 7 centers are located in zones with very severe and severe damage and 1 center has been in zones with very severe damage.

5. Conclusions

According to what was mentioned, the risk of earthquakes throughout Kerman province was inevitable and effects on available and most populated places in Kerman. For this reason, the necessity of public consciousness against probable damages of the phenomenon is vital. Determining a safe distance and space to population centers than type of fault and fault structure and also retrofitting of urban buildings, including basic strategies for reducing damage, are important in the earthquake in Kerman.

The results show that among total absorbing centers of population in Kerman, 22.8% of the training centers, 34.5% of health care centers, 22.2% of administrative centers, 14% of business centers, and 18.9% of fitness centers in the area are located in the risk of severe and very severe degradation. In other words, among 973 absorbing centers of population, 190 centers in Kerman area with high damage and very much damage and 206 centers are located in an area with moderate damage. This means that the entire population of Kerman in 396 absorbing centers is located in medium to high risk of damage. According to population aggregation in these centers and the practical importance of these centers in spatial structure, predicting the retrofitting strategies, such as public education and crisis management, leads to reduce damage during seismic events that are very likely to appear.

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