

The social and physical vulnerability assessment of old texture against earthquake (case study: Fahadan district in Yazd City)

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Abstract The disasters can result in considerable damages to urban structures. In vulnerable cities, the amount of economic damages and fatalities is highlighted. The review of the literature indicates the urban vulnerabilities related to building qualification and the society situation. In this paper, some factors that can affect the vulnerability of old cities in Iran are listed. For evaluating the importance of each factor in identifying the vulnerability of Fahadan district, the AHP method is used. Twenty-five academic-related disaster management experts helped to achieve the priority of factors. Two vulnerability maps of the district were achieved by using the weight of factors obtained from the AHP model and geographic information system (GIS). Maps' analysis shows that places with high vulnerability cover all parts of the district, and residential parts of district suffer from susceptibility. Also, the results show that less vulnerable parts of the district surround the district. Reconstruction and rehabilitation measures can decrease the vulnerability value of Fahadan district.

Keywords Historical region · Yazd City · Vulnerability · Cultural heritage · Fahadan district

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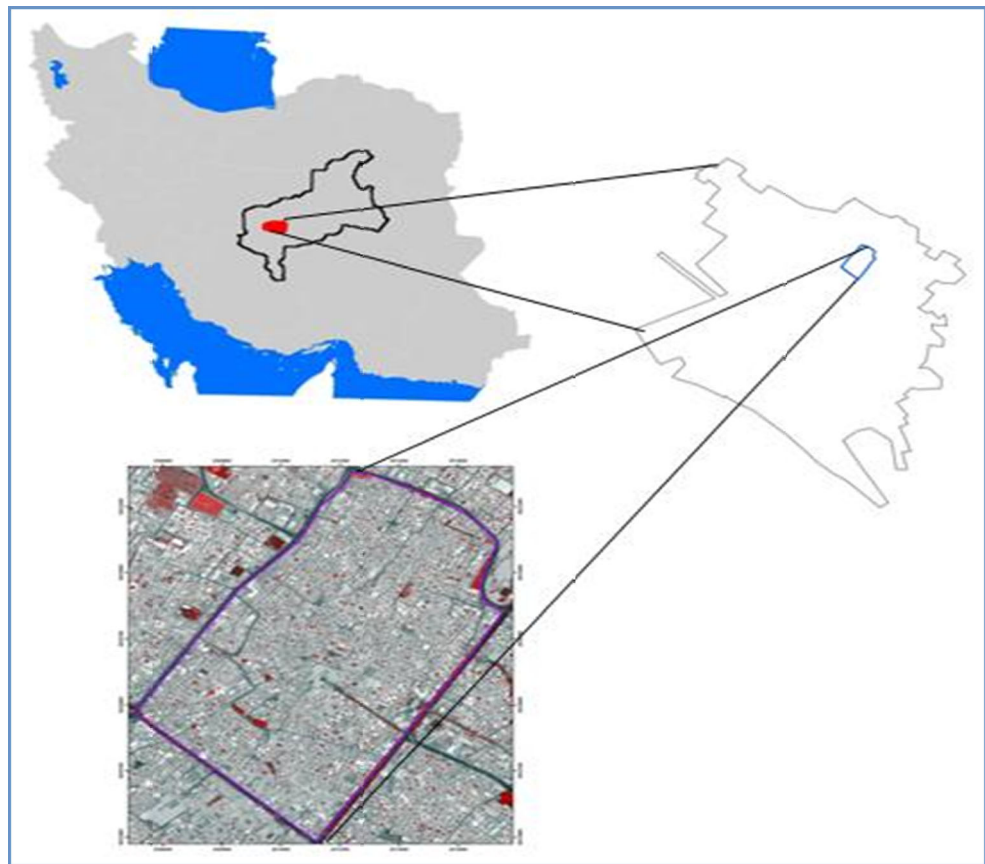
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Introduction

The rapid world population growth is likely to further increase the impact and severity of any disaster. Disaster management, as such, needs to be placed within a holistic setting to ensure that each and every disaster is viewed as a shared responsibility. To this aim, it is imperative to consider a number of influences, which include “economic, social, cultural, institutional, political, and even psychological factors that shape people’s lives in disaster situations” (McEntire et al. 2002).

Iran, Afghanistan, and India are countries with a relatively high vulnerability to earthquake hazards (UNDP 2004). Iran is a disaster-prone country, which experiences many disasters such as earthquakes every year (Omidvar 2010). Historical data show the occurrence of a major earthquake every 2–3 years in Iran. In the 20th century alone, 20 major earthquakes claimed more than 140,000 lives, destroyed several villages and cities and caused extensive economic damages to Iran (UN Flash Appeal 2004). Most of the fatalities and damages are due to buildings collapsing, which is some 90 % of direct deaths. Advances in structural design were applied to new structures and, to a lesser extent, to the rehabilitation of existing structures. Nevertheless, there are many more old structures than newly constructed ones. The main and probably the only way to lessen risks in urban areas is to reduce building vulnerability (Lantada et al. 2008). On the other hand, the economic and social situation of societies can affect their vulnerability. According to recent studies on the earthquakes occurred in the world, living in seismic prone regions is not the only reason of high vulnerability even the poverty or absence of strong communications can increase the vulnerability of society. Poor and low income people in urban areas live in houses with materials of low durability against earthquake and weak or vulnerable areas such as informal settlement areas, rivers boundaries, power transmission lines,

Fig. 1 Fahadan district as case study



and slope regions, which in case of natural disasters such as earthquake, have very high vulnerability compared with other urban dwellers. (Ahadnejad 2011). Social vulnerability to disasters relates to gender, class, race, culture, nationality, age, and other power relationships. Also, emergency managers have the additional task of identifying those people who may be the most vulnerable (Cutter and Emrich 2006).

Social and physical assessment is a process of collecting, organizing, and analyzing information about a community or a region gathered through processes of stakeholder engagement and building analysis. Vulnerability is not only the result of exposure to high risk regions; even some other economic and social process can make vulnerable places.

Physical vulnerability factors are related with the indicators of built-environment. Social vulnerability is a measure of both the sensitivity of a population to natural hazards and its ability to respond to and recover from the impacts of hazards (Cutter and Finch 2008).

The social and physical vulnerabilities interact to produce the overall place vulnerability. This paper provides the conceptual basis for a social and physical assessment framework that, if implemented, will assist in identifying areas of priority for local government intervention. Iranian government tries to reduce the vulnerability of the old texture of cities against natural disasters including earthquake. So, some studies should be conducted to assess the vulnerability of old districts in old cities.

In this paper, we examine the social and physical vulnerability of Fahadan district in Yazd City in Iran.

Case study

Unfortunately, most of old textures are vulnerable against earthquake in Iran. Among Iranian cities, Yazd City has maintained its physical and functional integrity but is not safe enough

Table 1 Area of different users in Fahadan

User	Residential user	Training user	Welfare user	Communication and transportation user	Arid and desolate and outdoors
Area (ha)	92.9	0,86	6.6	10.6	0.66

Source: Fallah Aliabadi et al. (2011)

against earthquake. With attention to exhaustion of old parts of the city and weakness of lifelines and lack of enough experience in strengthening the old buildings, using efficient strategies for hazard mitigation is necessary. After the destructive earthquake in Bam City on December 26, 2003, and demolishing all the historical parts of the city, the importance of attention to the old cities and protection of cultural heritage against earthquake has increased (Fallah Aliabadi et al. 2011).

Yazd is a very ancient city along the Silk Road, in the middle of the desert, in Central Iran. It is one of the oldest living cities of the world. In addition, due to its desert surroundings, it has developed a unique architecture and according to UNESCO, the first human settlement can date back to 5000 B.C. in Yazd. Its old part is built with bricks mixed with mud, clay, straw, and earth. Nowadays, this city is a mixture of old, traditional, modern urban context. The old part of Yazd City is being preserved and has a unique structure. The old district of Yazd consists of many districts or Mahalleh. Fahadan is one of the oldest districts of Yazd (Fallah Aliabadi et al. 2011). Figure 1 shows the Fahadan location in Yazd. This district with its unique uniform city texture and important famous buildings plays a special part in attracting tourists from inside and outside the country. It is because of this situation as well as the social reputation of the people who resided there in the past. Fahadan district has many characteristics which have remained unchanged to present. Fahadan district is a uniform assortment consisting of valuable buildings, monuments, and many historic houses like the Jame'e Mosque that is built about 700 years ago or Alexander Yazd prison as a very old and historic location that is associated with Alexander the Great of Macedonia (around 300 B.C.).

It was observed from the results of field studies and surveys that the level of education and economic status of most households is low. The traditional society in Fahadan is composed of families who have mainly been residents of the district for more than 20 years. Most of the residents know their neighbors and visit them. They participate in different religious programs in mosques and religious sites and know significant people of their neighborhood. However, their social work is not formally accredited (such as membership in a formal organization) and is mostly based on friendly and neighborly relations. In the second society, which is comprised of non-native residents of the district, lack of social ties in the neighborhood can be seen. Often, families do not know each other and do not communicate with each other and also do not take on any especial role in the social programs. Collective interests, affiliations and friendships are less noticeable, and on the other hand, the density of households in the same neighborhood is lowered. However, this group seems less likely to participate in risk reduction programs, and local residents have less confidence on them. Since the level of trust, cooperation and neighborly relations

Table 2 Building materials used in Fahadan district

Building materials	Adobe and mud	Steel and brick	Joist and block	Combination of materials
Percents	51.7	43.5	0.74	4.04

Source: Fallah Aliabadi et al. (2011)

which are among the major factors of a social asset are available in Fahadan district, though less than before.

Fahadan had a population of 5600 in 2011 and has an area of 101.7 ha. Different users in this district have been shown in Table 1.

The most building materials that were used in this district are adobe and mud. Different building materials have been shown in Table 2.

Background

Urban vulnerability describes the degree to which socioeconomic systems and physical assets in urban areas are either susceptible or resilient to the impact of natural hazards. Over the past two decades, vulnerability has come to represent an essential concept in hazards research and in the development of mitigation strategies at the local, national, and international levels (Rashed and Weeks 2003). For most of the twentieth century, disaster management focused on the physical world, emphasizing infrastructure and technology. The concept of social vulnerability within the disaster management context was introduced in the 1970s when researchers recognized that vulnerability also involves socioeconomic factors that affect community resilience (Juntunen 2005). Social vulnerabilities are largely ignored, mainly due to the difficulty in quantifying them, which also explains why social losses are normally absent in after-disaster cost/loss estimation reports. Instead, social vulnerability is most often described using the individual characteristics of people such as age, race, health, income, type of dwelling unit, employment (Cutter et al. 2003). The concept of measuring or assessing social vulnerability to

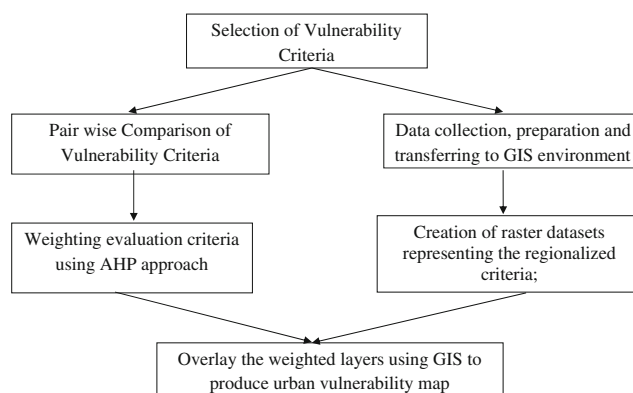


Fig. 2 General process of vulnerability Analysis

Table 3 The social and physical factors

	Main criteria	Following criteria	Vulnerability
Criteria for physical vulnerability assessment	Width of streets	0–6 m	High
		6–12 m	Medium
		12–45 m	Low
	Building materials	Adobe and brick	High
		Brick and steel	Medium
		Concrete or steel	Low
	Age of buildings	Before 1950	High
		1970–1980	Medium
		1980–2011	Low
	Population density	0–50 (person per hectares)	Low
		50–200	Medium
		More than 200	High
	Number of floors	One floor	Low
		Two floors	Medium
		More than two floors	High
	Distance to open sites	0–100 m	Low
		100–200 m	Medium
		More than 200 m	High
Distance to medical centers	0–500 m	Low	
	500–1000 m	Medium	
	More than 1 km	High	
Distance to fire stations	0–500 m	Low	
	500–1000 m	Medium	
	More than 1 km	High	
Criteria for social vulnerability assessment	Age	More than 60	High
		15–60	Medium
		Less than 15	low
	Gender (men/women)%	Less than 96	High
		96–105	Medium
		More than 105	Low
	Commercial and tourism development (%)	Less than 25	High
		25–50	Medium
		More than 50	Low
	Cultural buildings	Ruins	High
		Disused	Medium
		Used	Low
	Migrant (into/out of) block	More than 10	High
		6–10	Medium
		Less than 5	Low
	Residence factor (household number/house number)%	More than one	High
		One	Medium
		Less than one	Low
Residence consent from living in Fahadan neighborhood (%)	Less than 25	High	
	25–50	Medium	
	More than 50	Low	
Security feeling (%)	Less than 20	High	
	20–60	Medium	
	More than 60	Low	

Table 4 Magnitude of importance for pairwise comparison

Intensity of importance	Definition
1	Equal importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong or demonstrate importance
8	Very, very strong
9	Extreme importance

Source: Saaty (1990)

natural hazards has been explored widely in emergency and disaster literature. However, research has largely focused on qualitative assessment methodologies rather than quantitative risk modeling (Cutter and Emrich 2006). Dwyer et al. (2004) used some indicators in categories including society, security, setting sustenance, and shelter. These indicators are a collection of physical, structural, economic, and lifestyle factors chosen to measure a community’s vulnerability. Flanagan et al. (2011) describes the development of a social vulnerability index (SVI) for use in disaster management and examines its potential value by exploring the impact of Hurricane Katrina on local populations for illustration. The domains that form the basis of the SVI in this paper are socioeconomic status, household composition and disability, minority status and language, and housing and transportation. Armas and Gavris (2013) examined two multicriteria methods (the SVI model and the spatial multicriteria social vulnerability index (SEVI model)) that aggregate complex indicators, aiming to reveal the social vulnerability of the city of Bucharest in an earthquake context and to explore the statistical results in a spatial approach.

A multicriteria evaluation model of earthquake vulnerability in Victoria, British Columbia, is another paper that presents a

Table 6 Priority of physical factors

Priority	Factors
1	Building materials
2	Population density
3	Number of floors
4	Width of streets
5	Age of buildings
6	Distance to medical centers
7	Distance to open sites
8	Distance to fire stations

multicriteria model for combining physical, social, and systemic components, moving toward a more comprehensive assessment of vulnerability. Systemic vulnerability indicates the travel distance to hospitals and trauma centers. The vulnerability scores produce the resulting earthquake vulnerability map. Highly vulnerable areas cluster around the edge of the city of Victoria and are recommended as priority neighborhoods for earthquake preparedness and response programs (Walker et al. 2014).

Ahadnejad (2011) attempted to assess social vulnerability of Zanjan City to earthquake using GIS analytical capabilities and AHP method. In another study, Ahadnejad (2009) measured urban vulnerability against earthquake in a GIS system using analytical hierarchy process (AHP). He also mentions some scenarios of earthquake with different magnitude and calculates the fatalities and economic losses. Fallah Aliabadi et al. (2011) reviewed the total situation of Fahadan district in Yazd City and mention an emergency operation plan (EOP) for planning and managing the situation before and after the earthquake occurrence in that district. Aghataher et al (2008) assessed the vulnerability of Tehran against earthquake by using two categories of criteria: building situation including (a) building stories(1–3, 4–15, and more than 15); (b) building’s structure type (weakly built or poorly constructed, sturdy or masonry, well-built or not reinforced, and well-built and reinforced); (c) building’s age (before 1966, 1966–1975, and

Table 5 Pairwise comparison matrix for physical vulnerability analysis

Factors	1	2	3	4	5	6	7	8	Row multiplied value $m_i = \prod_{i=1}^8 a_i$	Unnormalized value $W_i = \sqrt[8]{m_i}$	Normalized value
Width of streets (1)	1	0.33	1	0.5	0.5	2	3	3	1.5	1.02	0.12
Building materials (2)	3	1	3	2	2	5	5	4	3600	1.66	0.2
Age of buildings (3)	1	0.33	1	1	0.5	1	2	1	0.33	0.93	0.11
Population density (4)	2	0.5	1	1	2	2	4	3	48	1.27	0.15
Number of floors (5)	2	0.5	2	0.5	1	2	3	2	12	1.16	0.14
Distance to open sites (6)	0.5	0.2	1	0.5	0.5	1	1	1	0.025	0.79	0.09
Distance to fire stations (7)	0.33	0.2	0.5	0.25	0.33	1	1	0.5	0.002	0.7	0.08
Distance to medical centers (8)	0.33	0.25	1	0.33	0.5	1	2	1	0.03	0.8	0.1
										8.34	

1976–2005) and resident population. This paper proposed a new approach using fuzzy-AHP approach in order to handle and manage the uncertainty and imprecision of weighting factors in earthquake disaster management.

Servi (2004) prepared the earthquake risk map using multi criteria decision-making method based on mathematics and spatial information systems. Keping et al. (2001) applied a decision making model for natural disaster events using the combination of GIS and multi criterion evaluation method. Rashed and Weeks (2003) applied a model for earthquake forecasting of cities using remote sensing and GIS and the role of GIS in forecasting the vulnerability of a city against earthquake. Bagherzadeh and Mansouri (2013) produced the Map of landslide hazard zonation using GIS and AHP at Golestan province in Iran. Kaliraj et al. (2013) also used GIS and AHP technique for Identification of potential groundwater recharge zones. Cova and Church (1997) modeled the community evacuation vulnerability by using GIS. Xiong et al. (2007) combined AHP method with GIS in evaluation of eco-environment quality in Hunan Province in China. Also, the eco-environment quality of all parts of the province was specified on the maps resulted from the evaluations. Cutter et al. (2003) identified the major factors such as age, gender, race, and socioeconomic status and the quality of human settlements characterizing social vulnerability to natural and environmental hazards. Cutter also created the SVI based on a set of 42 socioeconomic variables for the year 1990 at the county level. In another article, AHP model and GIS were used for applying a model for social vulnerability assessment in zone 6 of Tehran City. For assessing social vulnerability of individuals within households to risk from earthquake hazards four categories of population, housing, socioeconomic status, and physical distance were used as the main criteria (Bac-Bronowicz and Nobuyuki 2007).

Yeletaysi et al. (2009) proposed a framework that integrates the use of social vulnerability factor to the selection of preparedness actions for a catastrophic earthquake hazard planning and preparedness project. The four final selected factors in this paper were poverty level, lack of proficiency in English, vulnerable age groups, and disabled population. An

Table 7 Priority of social factors

Priority	Factors
1	Age
2	Residence factor (household number/house number)
3	Migrant (into/out of) block
4	Commercial and tourism development
5	Gender (men/women)
6	Cultural buildings
7	Security feeling
8	Residence consent from living in Fahadan neighborhood

Table 8 Weight of social and physical factors

Factor	Weight
Social	38.4
Physical	61.6

interdisciplinary approach for earthquake vulnerability assessment in urban areas is the title of a paper that assess urban earthquake vulnerability at household to neighborhood scale. The overall vulnerability index of Yalova province in the northwest Turkey determined by combination of structural vulnerability, geological vulnerability, economic vulnerability, and social vulnerability. As a result, a map showed the overall vulnerability for nine neighborhoods of Yalova and indicates that Bahçelievler is the most vulnerable neighborhood against earthquakes (Güzey ÖE et al. 2013).

Materials and methodology

Different methods have already been used to evaluate the vulnerability of cities against earthquake. This research has been carried out following Saaty's AHP that is a multicriteria mathematical evaluation method in decision-making process. AHP enables decision makers to assign a relative priority to each factor through pairwise comparison (Tahernejad et al. 2013). The results are used to calculate the geometric mean and normalized weight of parameters. Our research is based on GIS techniques that allow criteria derived from different sources like experts opinion to be combined in order to support vulnerability analysis. The capabilities of GIS in handling spatial aspects of conservation have boosted its use in the criteria-based evaluation for the prioritization and selection of potential conservation areas (Hamadouche et al. 2013). The result of combination of AHP method and GIS analysis is vulnerability assessment of the cities against the earthquake with higher accuracy (Rashed and Weeks 2003; Thirumalaivasan et al. 2003; Xiong et al. 2007). Figure 2 shows the general process of vulnerability assessment in this research.

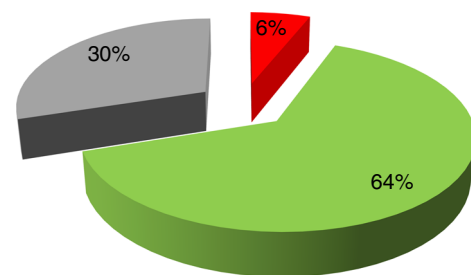


Fig. 3 Area portion of social vulnerability of Fahadan district

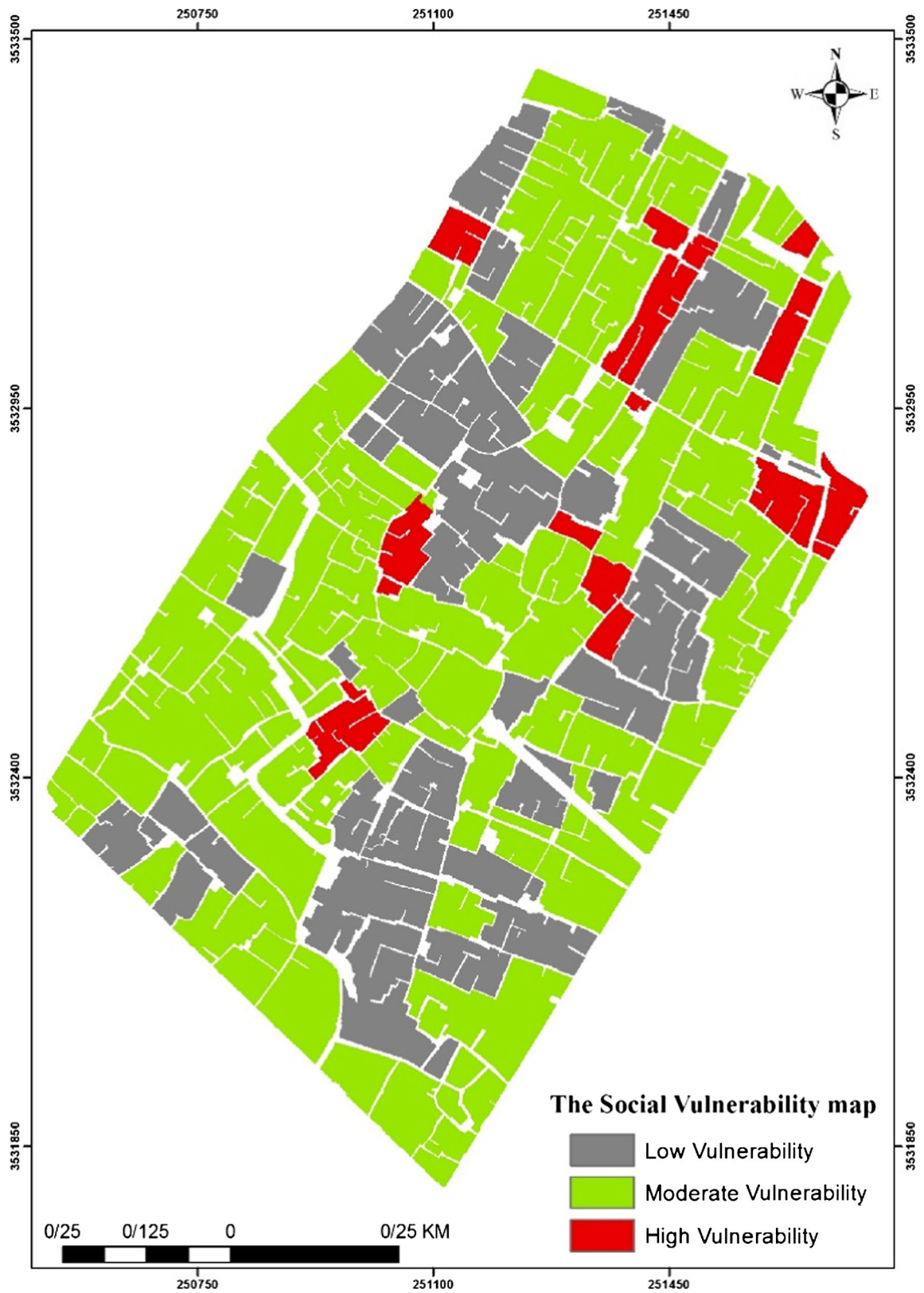


Fig. 4 The social vulnerability map of Fahadan district

Selection of vulnerability criteria

In this research, the social and physical vulnerability of Fahadan district against earthquake is assessed. Some appropriate criteria that are relevant to Fahadan district have been studied. In this regard, eight factors as the most important physical factors that adequately represent the decision-making environment and contribute toward the final goal have been selected. Generally speaking, some other factors such as geotechnical properties of Fahadan could be important for assessing the physical vulnerability; however, the fair homogeneity of subsoil properties in this district makes this factor less important comparing to the selected ones since its effects are almost the same for all buildings, so for prioritization purposes, this factor can be ignored. In other words, this factor is important for places where subsoil properties differ considerably. The physical factors are mentioned in Table 3.

Weight of evaluation factors

The weight of each factor was determined with AHP according to the expert opinion. AHP can be used in making decisions that are complex, unstructured, and contain multiple attributes. The decisions that are described by these criteria do not fit in a linear framework; they contain both physical and psychological elements (Nataraj 2005; Mian and Dai 1999). Saaty in his book, *Decision making for leaders*, mentions AHP as a method of breaking down a complex, unstructured situation into its component parts; arranging these parts, or judgments on the relative importance of each variable; and synthesizing the judgments to determine which variables have the highest priority and should be acted upon to influence the outcome of the situation (Saaty 1990).

The AHP method includes three major steps. The first step is generation of binary comparison matrices. From the judgments between two particular elements, a pairwise comparison matrix is constructed on a scale of 1–9, 1 indicating that the two elements are equally important, and 9 implying that one element is more important than the other. If an element is less significant than the others, then it is indicated by reciprocals of 1–9 values (i.e., 1/1 to 1/9). The pairwise comparison matrix prepared is used to derive the individual normalized weights of each element. Pairwise comparisons have been generated for the levels of the hierarchy contain expert opinion regarding the relative importance of criterion. Table 4 exhibits the scale of numbers that indicates how many times more important or dominant one element is than another element.

Thirty-five academic-related emergency management specialists filled the pairwise comparison matrix according to their opinions. The resulting pairwise comparison matrix for physical vulnerability analysis in Fahadan district is shown in Table 5.

In second step, the weight of different factors would be calculated. According to following relation, the weight of each

factor in binary matrix will be calculated. For example, the weight of the second factor “building materials” is calculated through the following process:

$$m_i = \prod_{i=1}^8 a_i$$

$$m_2 = 3 * 1 * 3 * 2 * 2 * 5 * 5 * 4 = 3600$$

$$W_2 = \sqrt[8]{m_2} = \sqrt[8]{3600} = 1.66$$

$$\text{Normalized value} = \frac{\sqrt[8]{m_i}}{\sum_{i=1}^8 W_i} = \frac{1.66}{8.34} = 0.2$$

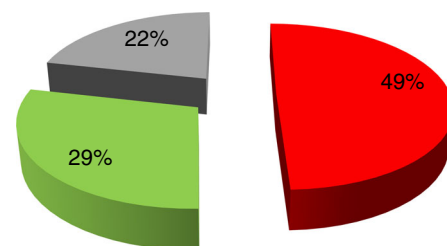
The weight of other factors will be obtained by using the above relations. The priority of factors according to prior calculations is indicated in Table 6.

In the third step, consistency ratio (CR) as an indicator of the degree of consistency or inconsistency will be obtained. If the CR is greater than 0.10, it is important to be careful to accept the resulting weights without changing the inputs to the pairwise comparison matrix, and also to feel confident that the matrix really reflects the user’s beliefs and does not contain any errors (Chen et al. 2009). The resulting CR for the pairwise comparison matrix was equal to 0.038. For obtaining the weight of social factors, the above process must be accomplished. The priority of social factors according to prior calculations indicated in Table 7.

For applying the overall vulnerability of Fahadan district, we should use the comparison matrix to calculate the weight of social and physical criteria. According to experts’ opinion who had been familiar with the especial situation of district like texture oldness or residents’ immigration, the weight of each criterion is as shown in Table 8.

Evaluation of the overall vulnerability

In order to evaluate the overall vulnerability, the weights for every criterion were calculated using AHP method and then every weight has been applied to its related layer using GIS software. This process was applied to both physical and social criteria. Then, spatial analyst extension and weighted overlay techniques in GIS platform were used to make the final vulnerability map.



■ High Vulnerability ■ Moderate Vulnerability ■ Low Vulnerability
Fig. 5 Area portion of physical vulnerability of Fahadan district

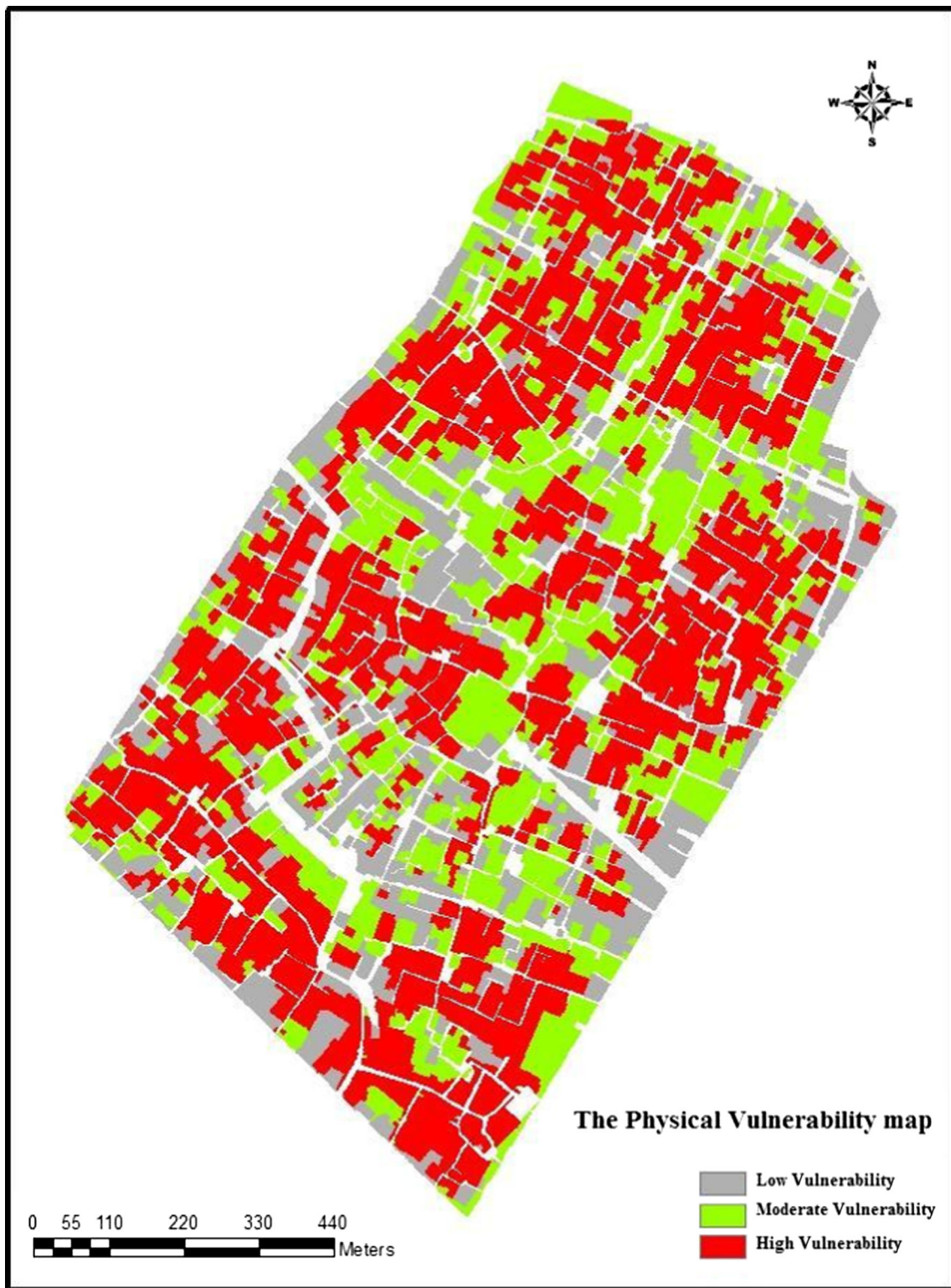


Fig. 6 The physical vulnerability map of Fahadan district

Results and analysis

Vulnerability maps resulting from AHP and GIS have shown different classes for which the degree of vulnerability against

earthquake varies from high vulnerable areas to low vulnerability. Vulnerability map is also reclassified with the equal interval classification method because we produced the criterion map layers with the same data classification method. This

makes the composite vulnerability map easier to understand and interpret. Fahadan has been broadly classified into three zones, as high, moderate, and low in terms of vulnerability in an event of earthquakes. The area portion of each vulnerability class value and the location of high vulnerable areas can be applied from each map analysis.

Analysis of social vulnerability map

The evaluation results of environmental social vulnerability (Fig. 3) showed that areas with high vulnerability are at an area proportion of 6 % and concentrated in the north of settlement zones. Some of these parts are depopulated and social problems like addiction is being widespread. The analysis of the inhabitant situation shows that the rate of migration is high and the age of residents is increasing. Also, the income level is low in these parts. The area portion of regions with medium vulnerability is 63 % that encompasses most parts of the district. The inhabitants in these parts are old, and most of them are women, which can raise the vulnerability of the region. Thirty-one percent of the district area includes the low vulnerability parts that most of them are near the markets and cultural buildings like Jame'e Mosque that is a place of residents' congregation for religious celebrations. Figure 4 shows the social vulnerability map of Fahadan district.

Analysis of physical vulnerability map

The obtained physical vulnerability map indicate that the high vulnerable zones cover about 49 % (49.49 ha) of the total area while about 29 % (30.1 ha) is classified as being the moderately vulnerable and 22 % of the case study area (23 ha) is classified as low susceptible (Fig. 5).

The high vulnerable zone covers most of the study area. Using weak materials like adobe and mud and the narrow roadways that make the services difficult both before and after earthquake occurrence are the most important reasons for increasing the vulnerability of the district. Other sparse places with less vulnerability represent some constructed buildings and the stores along the main streets around the district. Figure 6 shows the physical vulnerability map of Fahadan district.

Analysis of overall vulnerability map

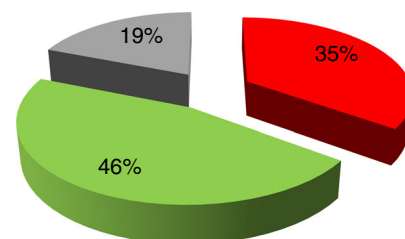
After class values were assigned for both social and physical map layers, these factor map layers were then overlaid with the weighted overlay technique using criteria priority/weight vector results in GIS environment. After the whole procedures were achieved, a vulnerability map for Fahadan district was obtained (Fig. 8). The final vulnerability map of Fahadan showed that the high vulnerability area proportion of district is about 35 % that covers the regions in north and south of the district, but the area proportion of moderate places is more and

is about 46 % that includes the central parts of the district (Fig. 7). The population density in these parts is higher than other places and the people participation in their works and programs like the ceremonies in special days is better. The areas around the district especially the stores and administration buildings are in low vulnerability parts of the district from both the social and physical aspects. Figure 8 shows the overall vulnerability map of Fahadan district. Table 9 shows the comparative results of three maps mentioned above.

Discussion and conclusion

According to the analysis of the field survey and on-site observations in Fahadan district and the scrutiny on architectural and structural typology and particular infrastructures, it is necessary to prepare a vulnerability map that helps the decision makers to analyze and find the vulnerable parts of the district which should adopt some strategies like reconstruction and rehabilitation plans that can improve the social and physical qualification of the district. For combining the AHP with GIS, it is needed to consider important factors that affect the vulnerability enhancement of society including both social and physical factors, because vulnerability can be examined not just as a social or a biophysical phenomenon but as a complex interaction of the two. These factors should have enough accordance with the special situation of the old texture of Fahadan district. The obtained maps show that the places with high vulnerability spread out of the district and all parts of district especially the residential buildings should be protected more. The physical vulnerability increases by passage of time because the residents are altering the form of buildings and on the other hand, some rules that enforce the owners or organizations like municipality or disaster management to improve the situation of district, like widening the roadways or demolishing the forbidden buildings, ease up the activities of trespassers.

On the other hand, the civic participation with municipal councils is very low due to lack of rapport with these institutions and also the non-native residents of the district. Consequently, lack of social ties can be seen in the neighborhood. There is the possibility of creating social problems in case classes which are held along with residents of other neighborhoods, and in this



■ High Vulnerability ■ Moderate Vulnerability ■ Low Vulnerability
Fig. 7 Area portion of overall vulnerability of Fahadan district

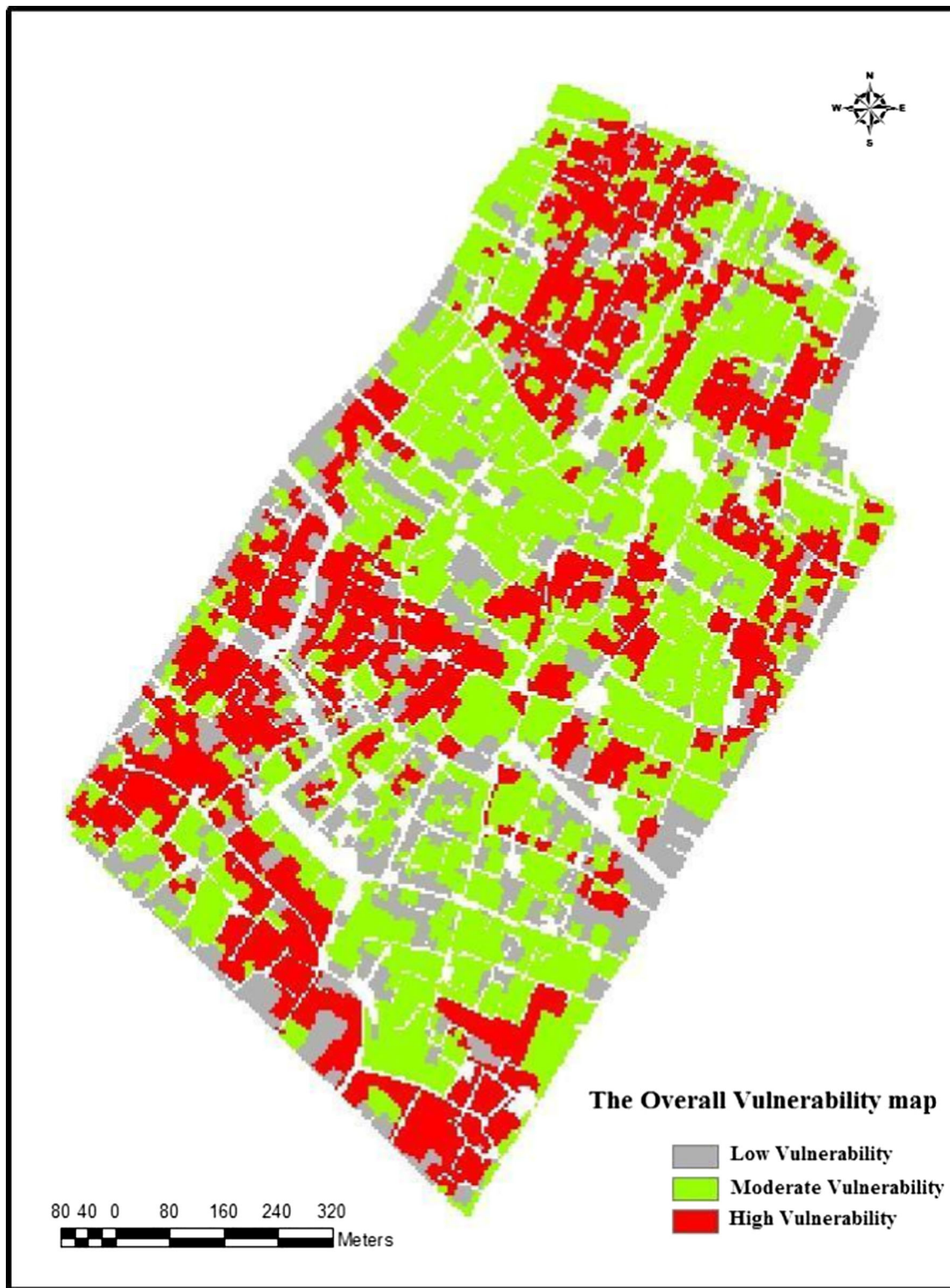


Fig. 8 The overall vulnerability map of Fahadan district

case, people will be less willing to participate in programs intended for risk reduction. Only the relations and trust among the current groups in the neighborhood and especially religious organizations can be mentioned as an available resource for

planning. Historical buildings including mosques and holy religious sites are among the most frequently used sites of this area.

Furthermore, according to the vulnerability map, the areas are situated in the area with moderate physical vulnerability

Table 9 The area portion of each vulnerability class value

	Social vulnerability map	Physical vulnerability map	Overall vulnerability map
High vulnerability parts portion	6 %	49.5 %	35 %
Medium vulnerability parts portion	64 %	29 %	46 %
Low vulnerability parts portion	30 %	21.5 %	19 %

and low social vulnerability. On the other hand, these sites attract people from other places of Yazd on special occasions or on certain days of the week. As a result, these places cannot be considered as safe havens during an earthquake, unless they are retrofitted. However, Jame'e Mosque and the new religious site of Fahadan, due to being located in areas with low vulnerability, can be considered as two safe places in Fahadan district. Based on basic rules for disaster management and the lessons learned from the earthquake in Bam in 2003, the process of managing the situation and the recovery of the livelihood of the survivors and protecting the cultural heritage in district after earthquake that might happen in the future in Yazd, should be planned based on old texture conditions and according to rehabilitation and reconstruction measures. Some actions that relates to reconstruction measures should be done like facilitating for international investment and research on cultural heritage risk reduction, Implementation of reconstruction program (Seismic Retrofit of Historic Buildings, using seismic design code, train and license professional working in construction, strict control of construction practice, demolishing non-resistant buildings, make programs for new constructions that adopted to the district texture).

The assessment of damages in constructions, lifelines, properties and cultural heritage, establishment of order in district (access control and re-entry), control the inventories in cultural buildings and museums, punishment of thieves and other criminals, restoration and repair of electrical power, natural gas, water, sewer, and telephone, supporting local NGOs that love cultural heritage, establishing research institute on cultural heritage affairs in district, build social capital and public participation.

Also, the mitigation efforts can be targeted at Fahadan district and the development and integration of social and physical indicators will improve hazard assessments and make good use of the residential and cultural places in this district.

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