Evaluation of Physical Resilience of Karaj City, Iran, against Earthquake

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Original Article

Abstract

INTRODUCTION: Natural hazards, especially earthquakes, have resulted in mass casualties and damages in different parts of Iran. Therefore, it is necessary to take required measures in relation to risk reduction, preparedness and coping with earthquake effects. Regarding the fact that resilience is a relatively new concept, despite the great attention to this term and its abundant application in different fields, measuring the level of earthquake resilience, as well as creating and improving it in urban settlements is a challenging necessity.

METHODS: The review of literature was carried out first and the physical resilience indicators were deduced. Subsequently, a questionnaire was prepared for experts with the aim of weighting and prioritizing the indicators. Then the weight of them was calculated using the Expert Choice software and AHP (Analytic Hierarchy Process). After weighing, the indicators were prioritized. In the next step, the required information layers were prepared in accordance with the inferred indices in GIS software. After preparing the required layers and maps, a fuzzy function was used to standardize. Then, the weight of the layers was multiplied in the standardized indicators, and after calculating the layers, the final map of the physical resilience of Karaj City, Iran, against earthquake was prepared and analyzed.

FINDINGS: Karaj City is one of the most vulnerable areas to earthquake due to its place located in the southern slopes of Alborz and on active faults. According to the maps prepared in this paper, large areas of Karaj City, especially in the central regions, have formed vulnerable places, which in the event of an earthquake, will have huge casualties and damages in the urban areas.

CONCLUSION: It is suggested that the physical resilience of the living environment within the case study should be in accordance with the prioritization obtained in the article: 1) infrastructures, 2) buildings, 3) urban structure and 4) land use and natural factors. Also, spatial priorities should be observed in promoting urban resilience in accordance with the final map.

Keywords: Physical Resilience; Earthquake; Iran; Geographic Information System (GIS); Analytic Hierarchy Process (AHP)

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Introduction

Natural disasters have always been a major challenge for urban communities and have long threatened human settlements, infrastructure, and capital. Based on the statistics, incidents have increased over time and the vulnerability of urban communities (especially in developing countries) has had a rising trend. Experience shows that earthquakes destroy people's lives and in addition to widespread damage, leave devastating effects, especially on urban settlements.

Given the statistics available, 90% of Iranian cities are highly vulnerable to a 5.5 magnitude earthquake (1); Karaj metropolis is one of these cities due to its location on the southern slopes of Alborz and its position on active faults, as one of the most vulnerable areas to earthquakes the

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casualties and losses of which will be irreparable in the event of an earthquake.

Today, there are many changes in attitudes to accidents on a global scale. One of the most important ones in the area of risk management is the shift of attitudes from "reducing vulnerability" to "promoting resilience" (2). Recent studies indicate that resilience promotion can be effective as a progressive approach to cope with the effects of natural disasters and the sustainability of settlements. "Resilience" is the opposite of "vulnerability". In fact, resilience is the capacity of a society to be creative, preventive, and proactive in dealing with disasters; in some cases, resilience is referred to as the ability to withstand changes that can have negative consequences on human life and livelihoods (3).

Resilience is the ability of a system or community at risk to resist, avoid, absorb, or accommodate the effects of an accident (4). Resilience can easily relate to all stages and parts of disasters as well as crisis management (5). In other words, a "resilient society" is the one that is capable of absorbing the shocks of a risk and the ability to return to the pre-accident conditions or even better than them (6). Accordingly, focusing on resilience means more emphasis on the measures taken by the societies in the area of disasters and how to improve their capacity. It is worth noting that resilience is a broad and deep subject that encompasses hardware and software systems, with the "hardware systems" including buildings, infrastructures, structural, technical, and mechanical features and virtual systems, and the and "software systems" including family, community, human needs, behavior, and relationships, respectively.

In specialized literature, the term resilience is often used in the sense of "bouncing back" and has been derived from the Latin root resilio (7). Resilience is a form of foresight and the adaptability of cities without collapse at the time of the event (8). Resilience is a new strategy to empower communities by effectively utilizing their potentials and capacities (9). Simply put, resilience is the ability to cope with and resist future disturbances (10).

A resilience city is a stable network of physical systems and human societies. Urban resilience is a complex and multifaceted concept with various social, physical, economic, institutional, and managerial dimensions. Given the scope of the issue, only the physical dimension of resilience was focused on in the present study. "Physical resilience" includes the natural and artificial components of the city including "buildings", "infrastructure", "land uses", "urban texture and structure", and "natural factors". Table 1 represents the indicators of physical resilience against earthquakes.

Taking into account the existing challenges and problems in the field of disasters, investigation of "resilience against earthquakes" with a focus on the physical dimension of the urban system is one of the priorities of planning in Iranian cities and seems to be an indispensable and inevitable issue.

Table 1. Indicators of physical resilience against earthquakes

Buildings	Quality of buildings, technology, and materials (11), number of floors and height of buildings, density of buildings, stability, and weight of façade parts (12), strength and structure of buildings (13), architecture of buildings (geometry and symmetry) (14), burnout and age of buildings (15), implementation of buildings based on codes and standards (16), grading (fine or small-grained) (12), size and area of parts (17)
Infrastructure	Gas stations, power lines, water pipes, Internet network (18), water tanks, telecommunication towers (19), strength and distance from dams (14), crossroads and intersections (20), quantity and quality of accesses and passages (21), geometry and pattern of paths (14), strength of bridges and tunnels (18), confinement, compression, and penetrability of the block (12)
Uses	Proximity and compatibility of uses (22), density of uses (13), Flexibility and changeability of uses (23), variety of uses, type of uses (residential uses) (24), educational uses (25), sports uses, religious uses (14), suitable evacuation and resettlement uses, relief, service, and security uses, health and medical uses (16), livelihood and business uses, hazardous facilities (14), open spaces and empty areas, parks and urban green spaces (25)
Urban texture and structure	Urban texture order (regular, irregular), urban texture continuity (continuous, discontinuous) (13), urban texture compactness (20), urban form and pattern (14), urban signs (26), urban elements and furniture (21)
Natural factors	Faults (11), soil type (soil classification, erosion rate) (15), topographic and slope condition, climatic condition (27), possibility of geological hazards (landslides, subsidence, liquefaction)

Accordingly, the present study was carried out aiming to measure the physical resilience of Karaj City, Iran, to earthquakes by deriving the indices, determine their coefficients of importance, and prioritizing them using the geographic information system (GIS) and analytic hierarchy process (AHP). Then, the final map of the physical resilience of Karaj was prepared and solutions and interventions were presented to improve earthquake resilience of this city.

Methods

To assess the physical resilience of Karaj against earthquakes, the technical literature was first reviewed. The texts mainly consisted of articles, reference books, and online resources. Then, the main and secondary indicators of physical resilience at the urban scale were identified. After deducing the indicators, a questionnaire was designed for experts to weight and prioritize them; this questionnaire was completed by 36 experts and its reliability was approved by the Cronbach's alpha coefficient method using the SPSS software.

In the next step, the weight of the indicators was calculated using the Expert Choice software by the AHP method. After weighting, the indicators of the physical resilience against earthquakes were prioritized. It is noteworthy that each of these indices was capable of being presented as a map or an information layer using GIS. Accordingly, the required maps were prepared according to the indicators extracted in the GIS software. One of the limitations of the present study was the lack of data or shape files of about 10% of the indicators such as the "viability of the livelihoods and business after the earthquake" and "variability and flexibility of uses". Therefore, the weight of those indices was set to zero in the final calculations.

After preparing the information layers and maps needed in GIS, a fuzzy function was applied for standardization. In the next step, the weights of the layers were multiplied by the standardized indicators, and after overlaying the maps, the weighted layers were aggregated. Ultimately, the final map of physical resilience of Karaj against an earthquake was prepared and analyzed in three levels of low, medium, and high resilience.

In terms of validity and reliability, the validity of the study was evaluated from the perspective of the internal validity and external validity. In fact, validity and reliability indicate the accuracy of the method used in the study and the data collected (28).

As mentioned earlier, in this study, after deducing the main and secondary indicators of physical resilience against earthquake, a questionnaire was designed for experts to weight the indicators. To ensure the questionnaire standardization, the questionnaire was reviewed by five experts as pilot. After applying the corrections, the questionnaires were completed by some experts. Given that standard questionnaires do not require validation of the study data and only reliability needs to be assessed in them (29), the standardization of the questionnaire was confirmed based on the opinions of several experts.

However, the "external validity or reliability of the study" indicates the generalizability of the study findings to similar cases. Before a questionnaire can be used, its internal consistency must be determined (30). It is worth noting that the reliability of the questionnaire can be objectively measured. In this study, the Cronbach's alpha method was exploited to measure reliability. This method is one of the main and most widely used tests for reliability testing. This method yields values between zero and one (31). The closer the alpha value to one, the greater the reliability of the questionnaire.

Generally, the alpha values of greater than 0.7, between 0.5 and 0.7, and less than 0.5 indicate good reliability, average reliability, and lack of required reliability, respectively. In the present study, using the SPSS software, the Cronbach's alpha was calculated as 0.928 for the physical resilience indicators, indicating good external validity or reliability of the questionnaire. Therefore, the questionnaire was distributed among the specialists and its results were analyzed.

Findings

The case study in this study was Karaj City, as shown in yellow in Figure 1. Karaj consists of three main parts of Asara in the north, Karaj in the center, and Eshtehard in the south. In this study, after extracting the urban resilience indicators and weighting them by the AHP method, the physical resilience of Karaj against earthquakes was assessed using GIS.

In order to evaluate the physical resilience of Karaj against an earthquake, after deriving the resilience indices in Table 1, the indices were assessed and the weight of each index was determined using 36 questionnaires. In order to weight the indices, the AHP method was applied so that the hierarchical graph and the pair-wise comparisons matrix were formed and the criteria were evaluated in the range of priority of 1 to 9. Finally, according to Table 2, the weight of each index was calculated.

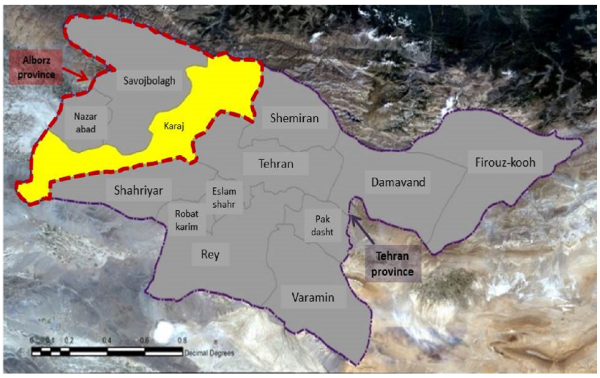

Figure 1. Location of Karaj in Alborz Province adjacent to Tehran Province, Iran

After calculating the weight of the indicators, prioritization of the main and secondary indicators was performed. As illustrated in Figure 2, of the key components of physical resilience, the most important was "infrastructure" followed by "buildings". The components of "urban texture and structure", "uses" and "natural factors" were in the next order of importance, respectively.

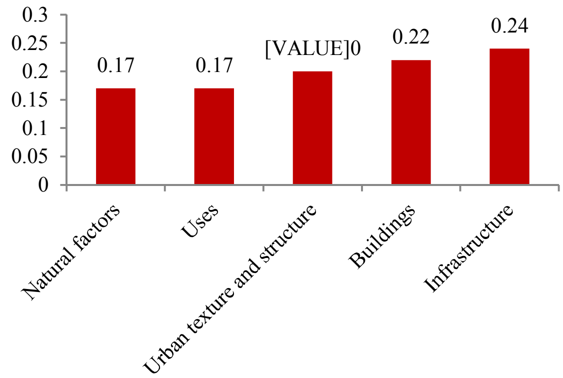

Figure 2. Prioritization of the main indicators of physical resilience

Table 2. Weighting of earthquake resilience indices

Main indicators	Secondary indicators	Indicator weight
Buildings (W = 0.22)	Impact of building architecture on vulnerability	0.26
	Density of buildings	0.25
	Grading status and level of occupancy (fine, coarse grained)	0.23
	Structural vulnerability	0.26
Infrastructure (W = 0.24)	Gas network risk status	0.12
	Power line risk status	0.12
	Water and wastewater network risk status	0.11
	Telecommunication and communication risk status	0.11
	Path systematization and access hierarchy	0.11
	Width and slope of passages, accesses, and intersections	0.11
	Path geometry and pattern (regular, irregular, etc.)	0.10
	Penetrability status of blocks	0.11
	Road infrastructure vulnerability (bridges, tunnels, etc.)	0.11
Uses (W = 0.17)	Usability and flexibility of uses	0.11
	Proximity and compatibility of uses	0.11
	Concentration of uses (centralized, decentralized)	0.11
	Diversity of uses	0.11
	Access to relief and security services	0.16
	Suitable uses for emergency evacuation and accommodation	0.14
	Post-earthquake livelihood and business viability	0.12
	Hazardous installations (gas stations, laboratories, etc.)	0.14
Urban texture and structure (W = 0.20)	Urban texture vulnerability (order, continuity, readability, etc.)	0.19
	Urban form and pattern (elements combination status)	0.17
	Blocking system (regular or irregular)	0.17
	Vulnerability of memories and signs (age, strength, etc.)	0.15
	Vulnerability of non-structural components and urban furniture	0.12
	Urban capacities to respond to an earthquake	0.20
Natural factors (W = 0.17)	Seismic status	0.52
	Landslide potential due to an earthquake	0.16
	Subsidence potential due to an earthquake	0.16
	Liquefaction potential due to an earthquake	0.16

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Table 3. Prioritization of the secondary indicators under study

Main indicators	Secondary indicators	Priority
Infrastructure	Gas network risk status	1
	Power line risk status	
	Water and wastewater network risk status	2
	Telecommunication and communication risk status	
	Path systematization and access hierarchy	
	Width and slope of passages, accesses, and intersections	
	Penetrability status of blocks	
	Road infrastructure vulnerability (bridges, tunnels, etc.)	
	Path geometry and pattern (regular, irregular, etc.)	3
Uses	Access to relief and security services	1
	Suitable uses for emergency evacuation and accommodation	2
	Hazardous installations (gas stations, laboratories, etc.)	
	Post-earthquake livelihood and business viability	3
	Usability and flexibility of uses	4
	Proximity and compatibility of uses	
	Concentration of uses (centralized, decentralized)	
	Diversity of uses	
Buildings	Structural vulnerability status	1
	Effect of architecture of buildings on vulnerability	
	Density status of buildings	2
	Grading status and level of occupancy (fine, coarse grained)	3
Urban texture and structure	Urban capacities to respond to an earthquake	1
	Urban texture vulnerability (order, continuity, readability, etc.)	2
	Urban form and pattern (elements combination status)	3
	Blocking system (regular or irregular)	
	Vulnerability of memories and signs (age, strength, etc.)	4
	Vulnerability of non-structural components and urban furniture	5

After prioritizing the main indicators in Figure 1, the secondary indicators were prioritized in the categories of "infrastructure", "uses", "buildings", and "urban texture and structure" (Table 3). Thus, according to the experts, "the risk status of the gas network and power lines" was in the top priority of the infrastructure indicators. In addition, "access to relief and security services" was rated as the most important indicator in the "field of uses". In the buildings sector, "structural vulnerability status" and the "impact of building architecture on vulnerability" were jointly of the first degree of importance. In prioritizing the indicators of "urban texture and structure", the "urban facilities and capacities to cope with earthquakes" was of particular importance and necessary measures had to be taken in this area (Table 3). Regarding the natural factors, the "seismic status of the area under study" had a higher degree of importance compared to the "possibility of geological hazards such as landslides, subsidence, and liquefaction" (Table 3).

In the other part of the study, the required maps were prepared according to the indicators obtained from the conceptual framework presented in Table 1. One of the main components of physical resilience was natural factors, one of the most important indicators of which was the seismic status of the area under study. Figure 3 demonstrates the position of the major and minor faults as well as the fault density. It should be noted that the less the distance between the faults and the greater the density of the faults, the less resilience to earthquake.

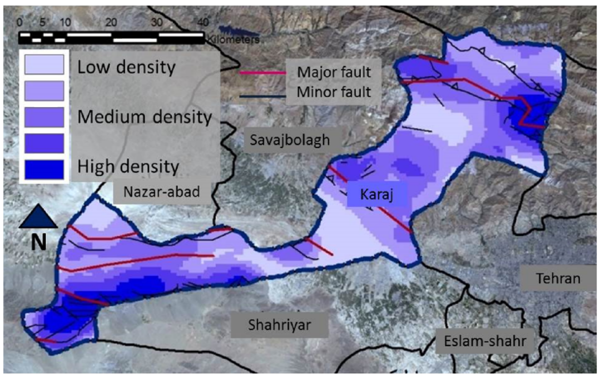

Figure 3. Fault map

Another indicator of natural factors that influence resilience is topography and land slope.

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As it can be observed in Figure 4, the slope of the study area ranged from zero to more than 30% presented in five categories. In the case of topography, the higher the slope of the earth, the less the earthquake resilience.

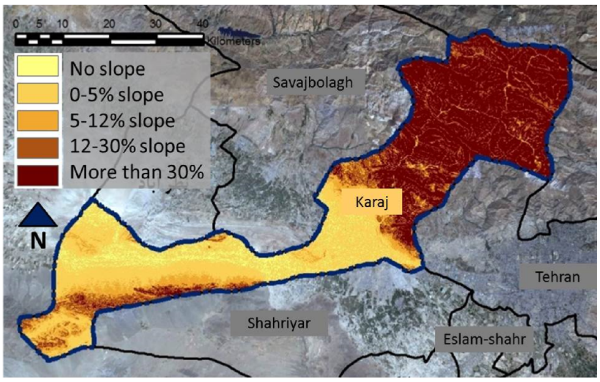

Figure 4. Topographic and land slope map

Regarding the natural factors, in addition to seismic conditions and the above cases, the possibility of geological hazards due to earthquakes also contributes to the urban resilience. The most common geological hazards that may occur due to earthquakes are landslides, subsidence, and liquefaction. For example, in Figure 5, the landslide-prone areas shown in red are indicated to be less resilient than other areas.

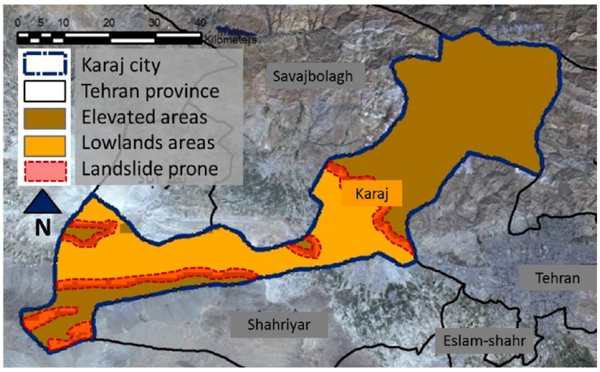

Figure 5. Map of landslide prone areas

According to Table 1, one of the key components of physical resilience is “buildings” and one of the key indicators of buildings is “building density”. Generally, in urban areas, the higher the building density, the less the earthquake resilience. Figure 6 depicts the density of buildings in the desired area; as shown in Figure 6, the density of buildings in the central parts of Karaj is higher than in the Asara (north) and Eshtehard (south) districts.

Given Figure 2, showing prioritization of the main indicators of physical resilience, “infrastructures” are the most important component of earthquake resilience.

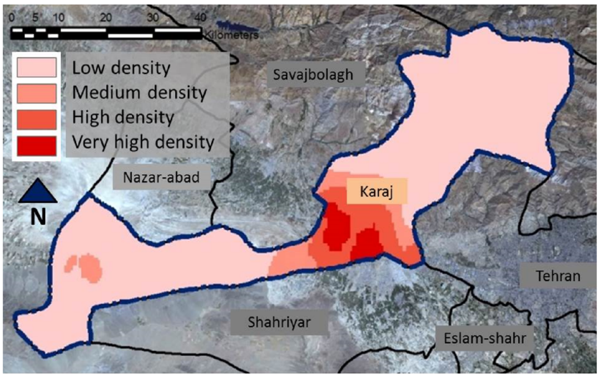

Figure 6. Building density map

Infrastructure mainly includes the risk status of the gas, electricity, water and wastewater, telecommunications and communications, as well as the transportation networks. For example, Figures 7 and 8 illustrate the vulnerability of the power lines and the transportation network in the city of Karaj, respectively.

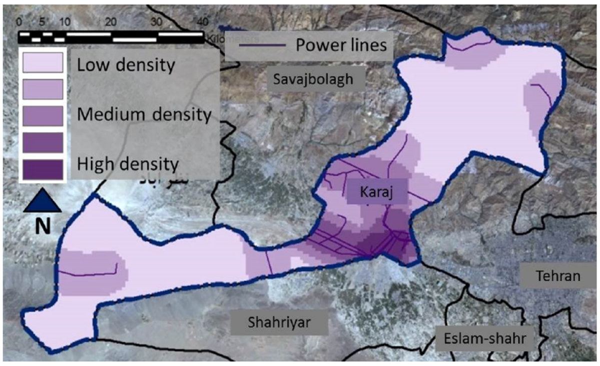

Figure 7. Power line map

The economic vulnerability status in a potential earthquake is indicated in Figure 9. The red areas show high economic losses in the central part of Karaj district and mainly in Karaj City; because there are more property and assets to lose in these areas because of population and construction congestion. The economic vulnerability is moderate and low in the northern and southern parts of the city, respectively.

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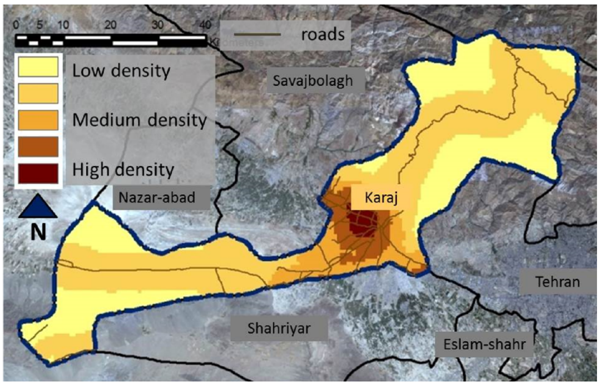

Figure 8. Transportation network map

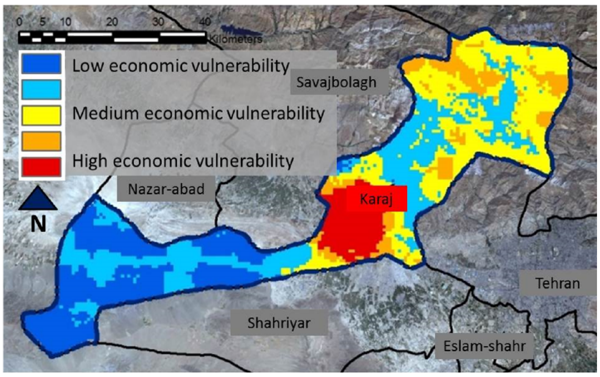

Figure 9. Economic vulnerability map

Figure 10 shows the location of important uses, including health centers and service centers within the study area.

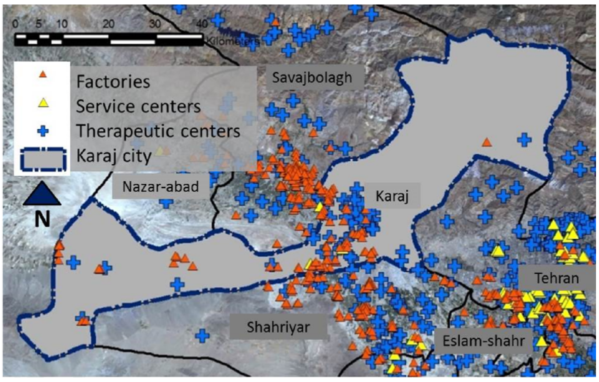

Figure 10. Location of important uses

In general, Figures 3 to 10 are examples of the most important indicators of physical resilience to earthquakes that were presented and interpreted. To obtain the final physical resilience map of Karaj, for all the deduced indicators presented in Table 1, the required maps were created and after applying the weights in accordance with Table 2, the layers were overlaid using a fuzzy function in GIS and the final resilience map was prepared (Figure 11).

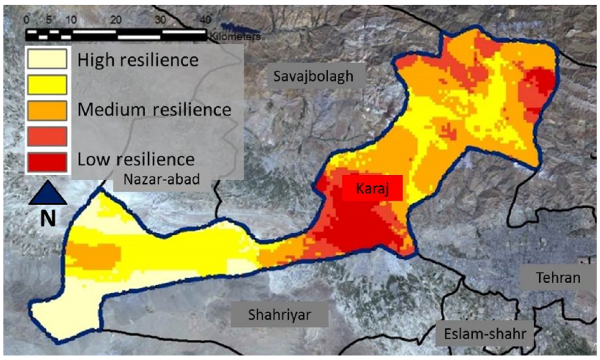

Figure 11. Final map of physical resilience of Karaj City, Iran, against an earthquake

Conclusion

Karaj City, due to its location on the southern slopes of Alborz and on active faults, is one of the most vulnerable areas to earthquakes that in case of an earthquake, its losses, and damages, especially in urban areas would be irreversible. Regarding the importance of identifying vulnerable zones and prioritizing indicators for managers, decision makers, and urban planners, this study was performed aiming to identify and analyze vulnerable zones, extract indicators based on the conceptual framework, and also prioritize and weight them.

In general, the final physical resilience map of Karaj (Figure 11) revealed three levels of relatively low (central areas), moderate (northern areas), and relatively high (southern areas) resilience. Given this map, about a quarter of the city area has very little earthquake resilience, and this vulnerable area is mainly located in the central parts of the city and in the city of Karaj. Overall, the vulnerability of urban areas was evaluated to be higher compared to the rural settlements.

It is noteworthy that despite the numerous service, security, relief, health, and treatment centers in the central parts of the district, especially Karaj City (Figure 10), due to the high vulnerability of the infrastructure, property concentration, population density, construction density, and congestion of old buildings, these areas have little physical and economic resilience in the event of a potential earthquake. In the central areas, there is more property to lose. The economic vulnerability is moderate and low in the northern and southern parts of the city, respectively.

Due to the increasing population and the location of Karaj City in the neighborhood of Tehran, suburban residence, and overcrowding in

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the study area have resulted in a significant decrease in resilience to earthquakes. Inadequate construction materials, infrastructure and building wear, mismatch between the width of the arteries and the height of the walls, and lack of access hierarchy are among the most important features that lead to low resilience of the central parts of the city of Karaj in the event of an earthquake.

This issue requires applied investigations, increased preparedness, consideration of the necessary measures, and a special focus on promoting earthquake resilience, and this will not be realized without the cooperation of all stakeholders and responsible entities, as well as public participation at the micro level (neighborhood level and neighborhood unit). It is noteworthy that based on the maps extracted, large areas of the city of Karaj, especially the central areas, consist of worn-out textures in which people would suffer great amount of financial losses and human casualties in the event of earthquakes.

The solution to this problem seems to be the effective application of the equipment, allocation of budget and facilities, and use of knowledge and experience of specialists and engineers with the aim of rebuilding the worn-out textures and vulnerable points in the final resilience map (Figure 11). Accordingly, it is suggested that physical immunization of the living environment for the people of Karaj city be carried out in accordance with the prioritization achieved in the present article, including: 1. Infrastructure, 2. Buildings, 3. Urban texture and structure, and 4. Natural uses and factors.

According to a survey from the experts and prioritization using the AHP method, the most important indicators in the fields of infrastructure, buildings, uses, and urban texture and structure were “gas network and power lines risk status”, “vulnerability status of structures and architecture”, “access to relief and security services”, and “urban facilities and capacities”, respectively, needing necessary actions to be performed in order to build capacity.

Moreover, spatial priorities in promoting urban resilience, red areas, should be in the first priority for safety measures, and efficient mechanisms for dealing with potential earthquakes. It is worth noting that reconstruction, retrofitting, and preparedness of important uses, including hospitals, relief centers, fire stations, security centers, and service centers in vulnerable areas are particularly necessary in terms of hardware and software and over-provisioning of executive entities.

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None

Conflict of Interests

Authors have no conflict of interests.

References

1. Gholami Y, Heidari Soreshjani R, Salimi Z, Brahman V. Planning with urban resilience approach. Kashan, Iran: University of Kashan; 2018. [In Persian]
2. Cutter SL, Finch C. Temporal and spatial changes in social vulnerability to natural hazards. Proc Natl Acad Sci U S A 2008; 105(7): 2301-6.
3. Seymour N. Strengthening community resilience. Vancouver, Canada: International Centre for Sustainable Cities; 2005.
4. United Nations Office for Disaster Risk Reduction (UNDRR). United Nations International Strategy for Disaster Reduction Annual Report 2016 [Online]. [cited 2016]; Available from: URL: https://www.unisdr.org/we/inform/publications/52253
5. Ostovar Izadkhah Y. Definitions and models of resilience in natural disasters. Journal of Disaster Prevention and Management Knowledge 2012; 2(2): 145-53.
6. Asian Disaster Preparedness Center. Community-based disaster risk management. Pathumthani, Thailand: Asian Disaster Preparedness Center (ADPC); 2006.
7. Sadeghloo T, Roknoddin Eftekhari A. Resilience of local communities against environmental hazards. Tehran, Iran: Tarbiat Moddares University Press; 2018. [In Persian].
8. Manyena B. Rural local authorities and disaster resilience in Zimbabwe. Disaster Prevention and Management 2006; 15(5): 810-20.
9. Berkes F, Colding J, Folke C. Navigating Social-ecological Systems: Building Resilience for Complexity and Change. Cambridge, UK: Cambridge University Press; 2003.
10. Abel N, Langston A. Evolution of a social-ecological system: Adaptation and resilience in the New South Wales rangelands 1850 to 2020 [Online] [cited 2001]; Available from: URL: http://www.cse.csiro.au/research/nswrangelands/pubs/popular_articles/Draft_Paper.pdf [In Persian].
11. Zangiabadi A, Mohammadi, Safaei H, Ghaed Rahmati S. Vulnerability indicators assessment of urban housing against the earthquake hazard (case study: Isfahan housing). Geography and Development 2019; 6(12): 61-79.

12. Zaker-Haghighi K, Majedi H, Habib F. Identifying effective indicators for typology of urban fabrics. Hoviatshahr 2010; 4(7): 105-12. [In Persian]

13. Mohammadpour S, Zali N, Pourahmad A. Analysis of seismic vulnerability factors in urban old texture with the approach of earthquake crisis management (Case Study: Sirus Neighborhood). Human Geography Research 2016; 48(1): 33-52. [In Persian]

14. Aslani F, Amini Hosseini K. An overview to the concepts, indicators, frames and models of earthquake resilience. Disaster Prev Manag Know 2018; 8(2): 119-36.

15. Cutter SL, Barnes L, Berry M, Burton C, Evans E, Tate E, et al. A place-based model for understanding community resilience to natural disasters. Glob Environ Change 2008; 18(4): 598-606.

16. Khazai B, Bendimerad F, Cardona OD, Carreno ML, Barbat AH, Burton CG. A Guide to Measuring Urban Risk Resilience: Principles, Tools and Practice of Urban Indicators [Online]. [cited 2015]; Available from: URL: https://www.cedim.kit.edu/download/Guidebook_URR_ME-July-2015.pdf [In Persian]

17. Azizi MM, Akbari R. Urban considerations in assessing the vulnerability of cities to earthquakes (Case study: Farahzad area, Tehran). Honar-Ha-Ye-Ziba 2008; 34: 25-36. [In Persian]

18. Farzad Behtash MR, Keynejhad MA, Pirbabaei MT, Asgary A. Evaluation and analysis of dimensions and components of Tabriz metropolis resilience. Hum Geog Res 2013; 18(3): 33-43. [In Persian].

19. Therrien MC, Tanguay GA. City strength in times of turbulence: Strategic resilience indicators. Proceedings of the Urban Affairs Association 41st Conference, Reclaiming the City: Building a Just and Sustainable Future; 2011 Mar. 16-19; New Orleans, Louisiana.

20. Pourjafar M, Khodaie Z, Pourkheiri A. An analytical approach in acknowledging the elements, indices and characteristics of urban sustainable development. Journal of Iranian Social Development Studies 2011; 3(3): 25-36. [In Persian]

21. Yaripour M, Hadizadeh Zargar S. Evaluation the qualitative and quantities indicators affecting on urban green space planning (the case of Miyaneh city). Journal of Urban Economics and Management: 2015; 3(10): 37-57. [In Persian]

22. Fallahi A, Jalali T. Resilient reconstruction from the point of view of urban design, after 2003 Bam earthquake. Honar-Ha-Ye-Ziba 2013; 18(3): 5-16. [In Persian]

23. Henestra D, Kovacs P, McBean G, Sweeting R. Background paper on disaster resilient cities, institute for catastrophic loss reduction, Toronto. 2004.

24. Cutter SL, Barnes L, Berry M, Burton C, Evans E, Tate E, et al. Community and regional resilience: Perspectives from hazards, disasters, and emergency management [Online]. [cited 2008]; Available from: URL: https://merid.org/case-study/community-and-regional-resilience-institute/wp-content/uploads/2013/03/ FINAL _CUTTER_9-25-08_1223482309.pdf

25. Aeini M. Measurement of quantitative measures of urban management in Mehr Housing plan. Quantitative Researches in Management 2011; 2(1): 141-53. [In Persian]

26. Zargar A, Ahari Z, Razaghi F. Development of a framework for measuring the resilience of a metropolitan area against earthquakes (case study: Harzevil neighborhood, Manjil, Guilan). Soffeh 2015; 25(69): 89-118. [In Persian]

27. Buckle P, Marsh G, Smale S. Assessing resilience, & vulnerability: Principles, strategies & actions [Online]. [cited 2001]; Available from: URL: http://www.proventionconsortium.net/themes/default/pdfs/CRA/EMA_2001_meth.pdf

28. Duas DE. Scrolling in Social Research, Trans. Nayebi H. Tehran, Iran: Ney Publications; 2018. [In Persian].

29. Barati N, Davoodpour Z, Montazeri M. Research method in environmental studies. Tehran, Iran: Sacco Publications; 2012. [In Persian]

30. Zumbo Bruno D, Gadermann AM, Zeisser C. Ordinal Versions of coefficients alpha and theta for Likert rating scales. J Mod Appl Stat Methods 2007; 6(1): 21-9.

31. Arab Zuzeni M, Hassanipour S, Baigi V. Understanding the cronbach's alpha concept: Necessity for original research studies. Iran J Med Educ 2014; 14(9): 831-2. [In Persian]

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