Evaluation of Urban Resiliency in Physico-Structural Dimension of Karaj Metropolis

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Abstract

Cities as the most complex man-made structures have been always exposed to natural and man-made hazards; these unpredictable risks have imposed serious impacts on urban areas. Meanwhile Urban Resiliency is the ability of the cities to respond quickly to inappropriate and unpredictable conditions, and to make them stand over the situation and enable them to remain stronger even after the disaster. Karaj as one of the metropolises of Iran and as the nearest city to the capital, has a close connection with economy and employment of Tehran. There has been always a risk of earthquake in Karaj City as geologically it surrounds with Tehran, Ray and Kahrizak faults which have considerable influences on Karaj resiliency. Thus the objective of this research is to formulate the effective indicators on Physico-Structural resiliency of Karaj and to assess them in the city based on the individual characteristics of each region. The indicators have been defined through literature review and in-depth expert-interviews. According to experts` answer to the questionnaire, the 11 indicators were found and weighted by AHP and the importance of each is determined in Physico-Structural resiliency of Karaj. Then, relying on spatial-occasional framework and using Arc GIS software, each of eleven indicators are defined as a layer which affects Karaj resiliency. By overlaying the layers and applying each one`s weight in the numerical range of zero to one, the final layer of Physico-Structural resiliency of Karaj is obtained in the numerical range of one to four. The result represents 1.96 as the lowest number of resiliency and 3.94 as the highest in Karaj. Also region No.1 and No. 8 have the lowest rate of Physico-Structural resiliency and regions No.12 and No.10 respectively has the most.

Keywords: Resiliency, Urban Resiliency, Physico-structural Dimension, Karaj Metropolis

1. Introduction

Nowadays, over half of the world's population are living in urban areas and the increasing rate of urbanization has alarmed urban experts and planners "what" risks impose diverse damages on "which" dimensions of the city, "when" they are imposed and "how". Iran is geographically and tectonically among the counties with high level of vulnerability against disasters and 70% of its population is living in disaster prone regions, so Iran is ranked 1st to 3rd in terms of fatality caused by these disasters (UNESCAP). It is clear that cities and their communities have to be more resilient and prepared against risks to increase the residents' safety and welfare (UNISDR, 2010). Resiliency is a new concept referring to the reduction of impacts and damages of disasters which is used to confront unknowns and uncertainties (Farzad Behtash et al., 2013: 1). The severity of natural disasters in urban areas has been always associated with unplanned urban development (Kavian, 2011: 2). Karaj, as the 5th largest city in Iran is located 35 kilometers west of Tehran and is highly interrelated with Tehran in terms of economy and employment. Also, being close to the Mosha-Fasham, Rey and Kahrizak faults as well as 700 hectares of deteriorated urban areas accommodated about one-third of the population made the evaluation of urban resiliency in physico-structural dimension more important In fact, this concept aims to reduce the cities' vulnerabilities and strengthen the citizens' ability to confront the risks of natural and man-made disasters (Mitchell, 2012: 3). The present article intends to recognize different dimensions of urban resiliency and clarify the variables affecting urban resiliency in physico-structural dimension. It also aims to practically fill the gap between theoretical identification of resiliency and measurement of the variables affecting urban resiliency in physico-structural dimension and ultimately, evaluate and measure its status in Karaj.

2. Theoretical framework
2.1. Concepts and definitions of resiliency

The term "resiliency" has been often used in references as "Bouncing back" rooted in the Latin term "resilio" that means "Jumping back". In some references, the root of this term is considered the Latin term "resalire" translated to jumping or rising backward (Gunderson, 2009: 19).
The concept of resiliency was first used three decades ago by Holling (1973), the famous Canadian The concept of resiliency has been defined in the field of natural disaster by other researchers like(Colten, Kates, &Laska, 2008; Cutter et al., 2003; Pais& Elliot, 2008; Vale &Campanella, 2005; Coaffee et al., 2008).

Table 1
Selected definitions of resiliency

Author	Definition
Folke, 2002	We use the concept of resilience—the capacity to buffer change, learn and develop— as a framework for understanding how to sustain and enhance adaptive capacity in a complex world of rapid transformations
UN/ISDR, 2005	The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure This is determined by the degree to which the social system is capable of organising itself to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures
Pendall et al., 2007	The determination that a person or a city has "recovered," or that an ecosystem is "stable," presumes that the analyst pays attention to some things but not to others.
Cutter et al., 2008	Resilience is the ability of a social system to respond and recover from disasters and includes those inherent conditions that allow the system to absorb impacts and cope with an event, as well as post-event, adaptive processes that facilitate the ability of the social system to re-organize, change, and learn in response to a threat. Vulner- ability and resilience are dynamic processes, but for measurement purposes are often viewed as static phenomena.
Zhou et al., 2009	Resilience, broadly defined as the capacity to resist and recover from loss, is an essential concept in natural hazards research and is central to the development of disaster reduction at the local, national and international levels.
Manyena, 2006	Disaster resilience could be viewed as the intrinsic capacity of a system, community or society predisposed to a shock or stress to adapt and survive by changing its nonessential attributes and rebuilding itself.
Carpenter et al., 2010	Carpenter defines resiliency with respect to the following three general features: (a) The ability of an SES to stay in the domain of attraction is related to slowly changing variables, or slowly changing disturbance regimes, which control the boundaries of the domain of attraction or the frequency of events that could push the system across the boundaries. Examples are soil phosphorus content in lake districts woody vegetation cover in rangelands, and property rights systems that affect land use in both lake districts and rangelands. (b) The ability of an SES to self-organize is related to the extent to which reorganization is endogenous rather than forced by external drivers. Self-organization is enhanced by coevolved ecosystem components and the presence of social networks that facilitate innovative problem solving. (c) The adaptive capacity of an SES is related to the existence of mechanisms for the evolution of novelty or learning. Examples include biodiversity at multiple scales and the existence of institutions that facilitate experimentation, discovery, and innovation
Klein, 2003	a system's capacity to absorb and recover from the occurrence of a hazardous event.
Bruneau and Tierney, 2007	Resilience reflects a concern for improving the capacity of physical and human systems to respond to and recover from extreme events. Resilient systems reduce the probabilities of failure; the consequences of failure—such as deaths and injuries, physical damage, and negative economic and social effects; and the time for recovery.
Wildavsky, 1991	Resilience is the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back.
Holling et al., 1995	It is the buffer capacity or the ability of a system to absorb perturbation, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables.
Horne and Orr, 1998	Resilience is a fundamental quality of individuals, groups and organisations, and systems as a whole to respond productively to significant change that disrupts the expected pattern of events without engaging in an extended period of regressive behaviour.
Mallak, 1998	Resilience is the ability of an individual or organisation to expeditiously design and implement positive adaptive behaviours matched to the immediate situation, while enduring minimal stress.
Miletti, 1999	Local resiliency with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community.
Comfort, 1999	The capacity to adapt existing resources and skills to new systems and operating conditions.
Paton, Smith and Violanti,2000)	Resilience describes an active process of self-righting, learned resourcefulness and growth— the ability to function psychologically at a level far greater than expected given the individual's capabilities and previous experiences.
Kendra and Wachtendorf,2003	The ability to respond to singular or unique events.
Cardona, 2003	The capacity of the damaged ecosystem or community to absorb negative impacts and recover from these.
Pelling, 2003	The ability of an actor to cope with or adapt to hazard stress.

The abundant definitions of resiliency against disasters and the use of this concept in several methods have made it difficult to give a one-size-fits-all definition. Among different dimensions of resiliency and several definitions of this concept, we have adopted the definition by Carpenter et al. (2001) as more appropriate and practical definition of resiliency used in many researches as a comprehensive definition. According to Carpenter (2001), resiliency is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks.

Given that research on resiliency is still in its initial steps, applied studies like the present research are essential to improve understanding of multidimensional nature of resiliency and its variables. More importantly, it is necessary to provide measures easily realized and applied in decision-making process. In this context, Bettencourt and Geoffrey (2010: 912) concluded that "developing a predictive framework applicable to cities around the world is a daunting task, given their extraordinary complexity and diversity". Resiliency indicators can provide a useful way for communities to investigate places and compare with other areas. Another gap in the literature is related to measuring resilience and how to assess a system's resiliency in general and urban resiliency in particular (Yosef Jabareen, 2013).

2.2. Dimensions of resiliency

In the literature of risks and disaster management, the term "resiliency" is used in various forms including economic, organizational, ecologic, social, constructional, engineering, critical infrastructures and communication systems; and the common aspect of all above forms is "the ability to withstand, resist, and positively react to a pressure or change". According to the research carried out on resiliency, it can be concluded that there is no single view about dimensions of resiliency including its definitions, concepts and dimensions. Each expert and researcher has suggested some dimensions for resiliency according to his individual studies, including Bruneau and Cutter among foreign experts and Rezaei and Farzad Behtash among Iranian researchers. Bruneau has introduced four dimensions for resiliency including technical, organizational, social and economic; Cutter, has presented six dimensions including ecological, social, economic, institutional or organizational, infrastructural, and social capital; Farzad Behtash, has discussed seven dimensions including risk mitigation, infrastructural, structural, environmental, socio-cultural, economic and management; and Rezaei, has introduced four dimensions including social, economic, institutional, and physical.
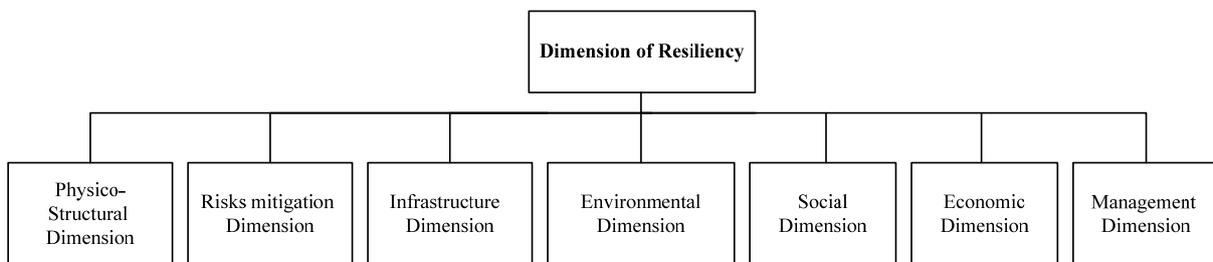

Fig. 1. Dimensions of resiliency

In the meantime, the attitude toward resiliency and how to analyze it play a key role in identification of the current state of resiliency. On the other hand, it affects risk mitigation policies and measures and how to deal with them. That's why explaining the relationship between resiliency and risks and mitigating their impacts are very important.

Eventually, seven dimensions including physico-structural, economic, social, environmental, management, risk mitigation and infrastructural have been considered for resiliency in this paper. Among these, the physico-structural dimension has been discussed in the present study because of its association with essential topics such as buildings durability, incompatible land-uses, and accessibility to open space, which are very crucial for evaluation of resiliency in a populated and earthquake prone urban area like Karaj.

2.2.1. Resiliency in physico-structural dimension

Urban safety and security have been always considered in urban settlement planning and planners have paid attention to this important issue in the design and construction of urban areas. City is a human, social, cultural, economic and physical phenomenon. Physical dimension is only one of the city's various specifications and buildings are considered as only one of physical elements of a city. Thus, physical planning can be a determinant factor in the reduction of earthquake risks (Mohammad Zadeh, 2015: 14). Therefore, prevention of buildings destruction is among the most important issues to reduce the costs of recovery and reconstruction (Kobayashi, 2004: 2).

A resilient city consists of a sustainable network of physico-structural systems and human communities. Physico-structural systems include the components of natural and built environment of the city, including roads and routes, buildings, facilities and environmental and natural characteristics of the city. Overall, physico-structural systems are considered as the body, bones, arteries and muscles of a city. During a disaster, physico-structural systems must be able to withstand high level of pressure and show good performance. If the systems have many un-repairable defects, then the process of recovery from disaster will be slow. A city without resilient physico-structural systems will be vulnerable against disasters (Gods chalk, 2003).

As a result, physico-structural dimension might play the most perceptible role of urban planning to reduce earthquake losses. Morphology, shape, structure and form of a city include various elements that can be organized by integrated urban planning and urban design, despite all of its difficulties.

2.3. Resiliency measurement frameworks and models

It is very complicated and challenging to find an appropriate way for measurement and evaluation of resiliency due to its multi-dimensional nature; because all the studies related to natural disasters aim at scientific, technological and operational improvement and the main purpose of such studies is disaster risk mitigation. In brief, the models are going to investigate flexibility of cities and communities in response to impacts, increase the ability to cope with the risks, and also reduce their vulnerability (Rafieian et al., 2011).

The models are used because they simplify complex issues in an understandable format; enable the users to adapt their conditions with the models; integrate different elements (for example, combination of social, political, physical, economic and environmental information) (Rezaei, 2010: 76). Also, the models proposed so far put more emphasis on conceptual facet of resiliency instead of measurement; including Tobin's Model (Tobin, 1999), Sustainable Livelihood (DFID, 2005), Linear-Temporal (Davis and Izadkhah, 2006), and Mayanga's Model (Mayunga, 2007) that imply to particular aspects of resiliency.

As a result, considering multi-dimensional nature of resiliency and the four main dimensions of resiliency accepted by the majority of scholars (social, economic, institutional and physico-structural), the appropriate model should be able to measure all resiliency dimensions. Since physico-structural dimension is measured in the present paper, we have tried to analyze all existing models and then select a comprehensive model. Thus, Cutter's Disaster Resiliency of Place model has been applied for the evaluation and measurement of resiliency against natural disasters.

Cutter et al. (2003: 8) have proposed a method for disaster resiliency measurement that can be considered as a standard approach for monitoring progress toward risk mitigation. They proposed basic disaster resiliency of place models emphasizing on the interactions between community variables. This method shows a complete set of factors causing vulnerability (Rafieian et al., 2011). It has been also designed to determine the relationship between resiliency and vulnerability. This method has theoretic basis and also can be quantified and used to overcome real problems in real places.

According to Cutter, there are four key sets of criteria including social vulnerability, infrastructures and built environment, natural systems at risk, risk mitigation and planning which are all essential to create a resiliency framework in the community. With an emphasis on the key set of infrastructures and built environment variables that have been introduced as physico-structural dimension in the present paper, urban resiliency of Karaj will be evaluated. It should be noted that the variables Cutter investigates under the category of infrastructure and built environment can be practically used as a guideline and outline in the present study, because the resiliency dimensions, especially physico-structural dimension, vary by the conditions of urban areas and communities. Thus, the authors have perceived and analyzed these variables in a logical process and then tried to coordinate these variables with Karaj conditions. However, the variables obtained in this paper had several practical differences with Cutter's variables, despite of some similarities.

The starting point of this model is the production of spatial multiple scale occurring within and between

man-made, natural and social environmental systems. The next step in this mode applies this scale, and creates a set of indexes and then investigates them in the real world.

Considering what mentioned above, Cutter's Disaster Resiliency of Place model has been finally selected as the most appropriate model in this research due to the available data. We have used Arc GIS software because of its possibility to examine each index as different information layers and also putting these layers on each other and then extracting the final resiliency map of Karaj in phsycio-structural dimension.

3. Research method

By nature, working on urban resiliency requires "complex thinking and complex methods" (De Roo & Jutosiniemi, 2010: 90) and enforces us to adopt a more comprehensive approach (Batty, 2007). In order to better understand the case study and the variables' distribution in this research, it is necessary to identify the variables affecting physico-structural dimension for evaluating urban resiliency of Karaj. For this purpose, along with the study of theoretical framework of resiliency, the frameworks and models proposed in other related research were also investigated to obtain appropriate indexes. Hence, the important stage in the creation of indexes is identification of strong appropriate variables explaining the factor.

One of the limitations and problems of studying and determining resiliency indexes is the lack of an integrated framework consolidated in both resiliency definition and indexes. On the other hand, resiliency aims to reflect unpredicted changes, needs and uncertainties; and this uncertainty results in the lack of fixed variables in this field; thus, it is very difficult to define appropriate indexes. Despite the problems mentioned, the most appropriate variables must be selected by considering the potential risks. Therefore, authors have identified earthquake as the most probable disaster in Karaj based on extensive studies on similar domestic and foreign cities and examining natural status of Karaj and also investigating the disaster risk in this city. Our goal is the formulation of the most appropriate relevant indexes and also coordination with natural and physical characteristics of the city. Since resiliency has been already considered at other micro and macro levels, it is essential to pay more attention to the scale of this study-the city-in order to properly perform the conversion of variable to index.

As well, in-depth expert-interviews have been carried out. The variables were also reviewed and then used to prepare the questionnaire. This questionnaire measures the value of each variable for prioritization and weighting each index in order to evaluate urban resiliency of Karaj. The questionnaire has been filled out by the experts, specialists, and scholars who are familiar with physico-structural variables of resiliency in the field of urban development and civil engineering.

At the end, considering the dimensions studied in the present research (physico-structural), the appropriate variables consistent with database and information available in Karaj were selected as the basis of Arc GIS software. Physico-structural dimension includes criteria and sub-criteria such as physical systems including buildings durability (buildings quality, façade material, number of floors), incompatible land-uses (density of deteriorated areas, population absorbance of land-uses, distance from dangerous functions/activities), accessibility (accessibility to street network, distance from emergency services like fire stations, hospitals and etc), open space (parks and green spaces, farms and gardens, barren lands, outdoor playgrounds, open parking sites), ground-bed profile (slope and fault) which are presented in Figure 2.

AHP (Analytical Hierarchy process) descriptive and comparative method has been used to analyze the information and questionnaires for weighting the indexes. Then, Arc GIS software has been used for the analysis of urban resiliency of Karaj in order to prepare a map. As a result, the variables are presented in a flowchart (Figure 2) that indicates selected definition, framework and model as well as selected variables.

4. Case Study

Iran is located in one of the highest disaster prone zones of the world. 31.7% of the country's area which resides70% of the population, is at the risk of natural disasters. UNESCAP in a report on the tectonic disasters stated that Iran is among the world's top 10 disaster prone countries that are ranked 1st to 3rd in terms of fatality caused by these disasters (Farzad Behtash et al., 2013: 2). Karaj (the capital of Alborz Province) with an area of 162 km^2 hosting a population of 1614626 plays a key role in the economy and survival of the country as one of Iranian Metropolises and the closest city to Tehran. Current population and growth of Karaj is the result of over-population of Tehran metropolitan area and absorbance of population surplus to its peripheral areas.
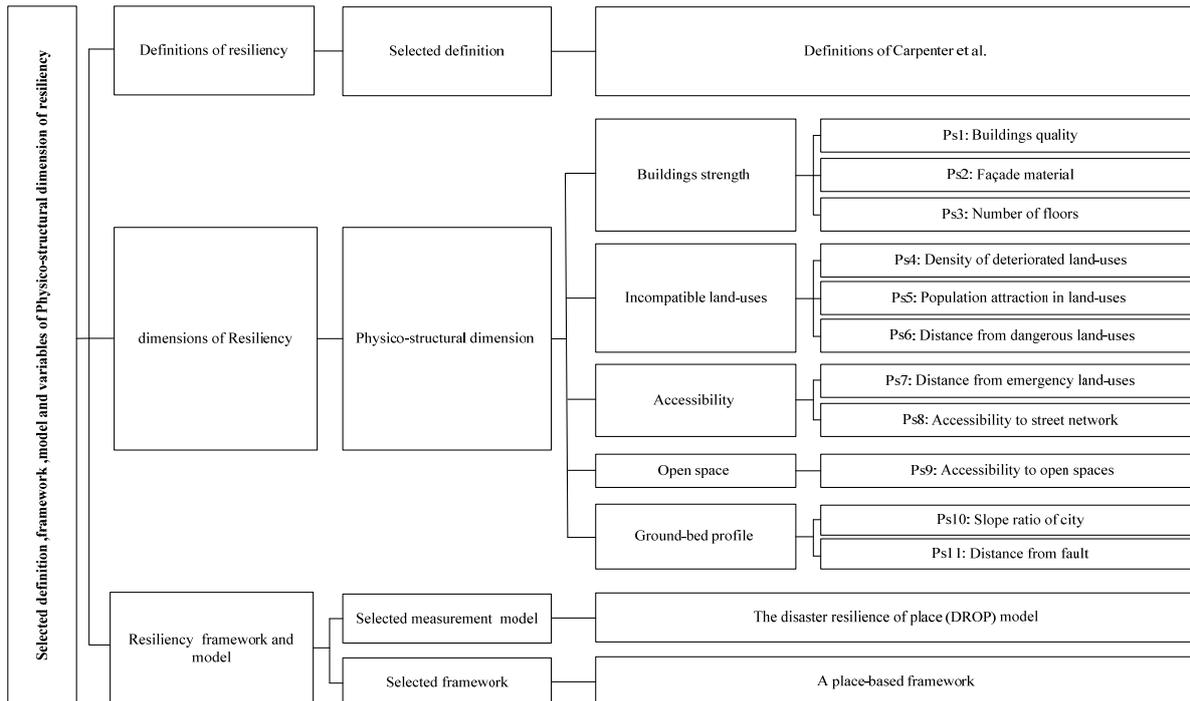
Fig. 2. Selected definition, framework, model and variables of Physico-structural dimension of resiliency
(Theoretical framework)

In the meantime, settlement centers and new-born village-cities in Karaj are dependent on Karaj and provide all their needs from there. Cities and towns in the northern Shahryar are the same. This hierarchal process brings multiple adverse outcomes including imbalanced growth and expansion of urban areas in Karaj, increased gap between current and expected level of service functions, as well as emergence and formation of marginal settlements immediately next to the cities and villages.

Karaj's urban fault analysis shows that this city is under the influence of Mosha-Fasham Fault, Northern Tehran and Garmdareh Pressure Fault. In addition to the faults mentioned above, a mild fault and some minor faults have been identified in different points of the city. These faults might slide due to greate earthquakes occurring near them. Thus, the risk of strong earthquakes along with these faults and other young faults in this zone is very high. In particular, the fault at the margin of Karaj highlands, which is of landslide type, compress great force in itself and then release it in the form of earthquake.

According to Iran's Seismic Hazard Map and International Earthquake Research Center, Karaj's urban area is located in a high to very high disaster prone area and it is also in a region with Mercalli intensity scale of 7 in terms of earthquake probability. Lack of attention to the fault privacy in the constructions and acceleration of construction, absence of practical and operational plans and policies for disaster management and the presence of deteriorated, vulnerable and marginal texture in the city have made doing such research essential.

5. Practical definition of indexes

In the present study, efforts have been made to determine the best and most efficient indexes of resiliency in urban scale which are appropriate for natural and physical characteristics of Karaj Metropolis, and eventually provide the best results for the resiliency in physico-structural dimension. In the following, first the definition and description of each index is provided and then the characteristics and features of each index in Karaj are explained using available information. Then, the index is examined and evaluated by the authors using Arc GIS software. The outputs are also obtained based on selected model that was mentioned earlier in the research. In brief, Disaster Resiliency of Place model is a method to create a major measure of resiliency against disasters that can also act as a criterion for monitoring the progress toward risk mitigation. Basic Resiliency of Place model focuses on the variables of society. This method shows a complete set of factors leading to vulnerability. Each index is presented as a different information layer in Arc GIS software.

Therefore, preparing a set of main factors that measure vulnerability is the key of urban resiliency.

By the combination of each index as a different information layer in Arc GIS and using Disaster Resiliency of Place model, the vulnerability of Resiliency Baseline Measurement model was proposed and evaluated as an index of pre-disaster vulnerability for the evaluation of resiliency against natural disasters. These layers were combined using Arc GIS analytical methods in order to illustrate the whole city's mixed model (Fig. 3).
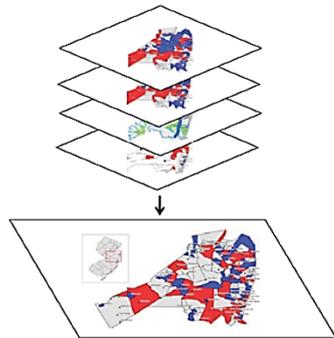

Fig. 3. Measuring DROP model in Arc GIS (Cutter et al., 2007)

In order to increase the precision and quality of outputs, Karaj City has been segmented into 100*100m cells in Arc GIS software. It allowed the investigation and evaluation of each index and ultimately urban resiliency in physico-structural dimension at each point of the city. With a glance at the available maps, the current status of each cell can be found. At the end, the resiliency in physico-structural dimension of Karaj is shown both in a map, which indicates the status of resiliency in each cell and also in a quantitative form (numerical) within four scales in each cell. It was concluded by combining these maps, determining the value and weight of each index with the help of questionnaires filled by resiliency experts and interview with the experts, and also using AHP method in Expert Choice software. Finally, the resiliency in physico-structural dimension, which is a function of the variables mentioned above, has been calculated using Equation 1:

$$PS = \sum_{i=1}^{11} (ps_i \, w_i)$$

6. Final evaluation of resiliency in physico-structural dimension of Karaj

In order to obtain the final result and determine resiliency in physico-structural dimension of Karaj, it was necessary to examine the effect of each index. So, in addition to examining the resiliency of each index in physico-structural dimension on the map, we had to weight each index according to its importance. As explained in the section Research Method, the weight of each index is as follows (Table 2):

Table 2
Weights of Evaluated indicators

Weight	Indicator	Ps_i
0.09	Buildings quality	Ps_1
0.04	Façade material	Ps_2
0.08	Number of floors	Ps_3
0.08	Density of deteriorated land-uses	Ps_4
0.14	Population attraction in land-uses	Ps_5
0.07	Distance from dangerous land-uses	Ps_6
0.12	Distance from emergency land-uses	Ps_7
0.1	Accessibility to street network	Ps_8
0.14	Accessibility to open spaces	Ps_9
0.08	Distance from fault	Ps_{10}
0.06	Slope ratio	Ps_{11}

The final evaluation of resiliency in physico-structural dimension of Karaj City has been extracted as a map with the help of Arc GIS software as well as using the weights and local-spatial framework. It was done by converting the map of each index into information layers and adapting them based on Cutter's resiliency of place framework in Arc GIS software and finally combining these layers. The resiliency in physico-structural dimension of Karaj was within a range of 1 to 4 and this range is divided into 4 situations, including: 1.96 to 2.79 (situation 1: the least resiliency in physico-structural dimension); 2.8 to 3.13 (situation 2); 3.14 to 3.44 (situation 3); and 3.45 to 3.93 (situation 4: the highest resiliency in physico-structural dimension). The results indicate that resiliency in physico-structural dimension was 1.96 in the worst and 3.93 in the best areas of Karaj.
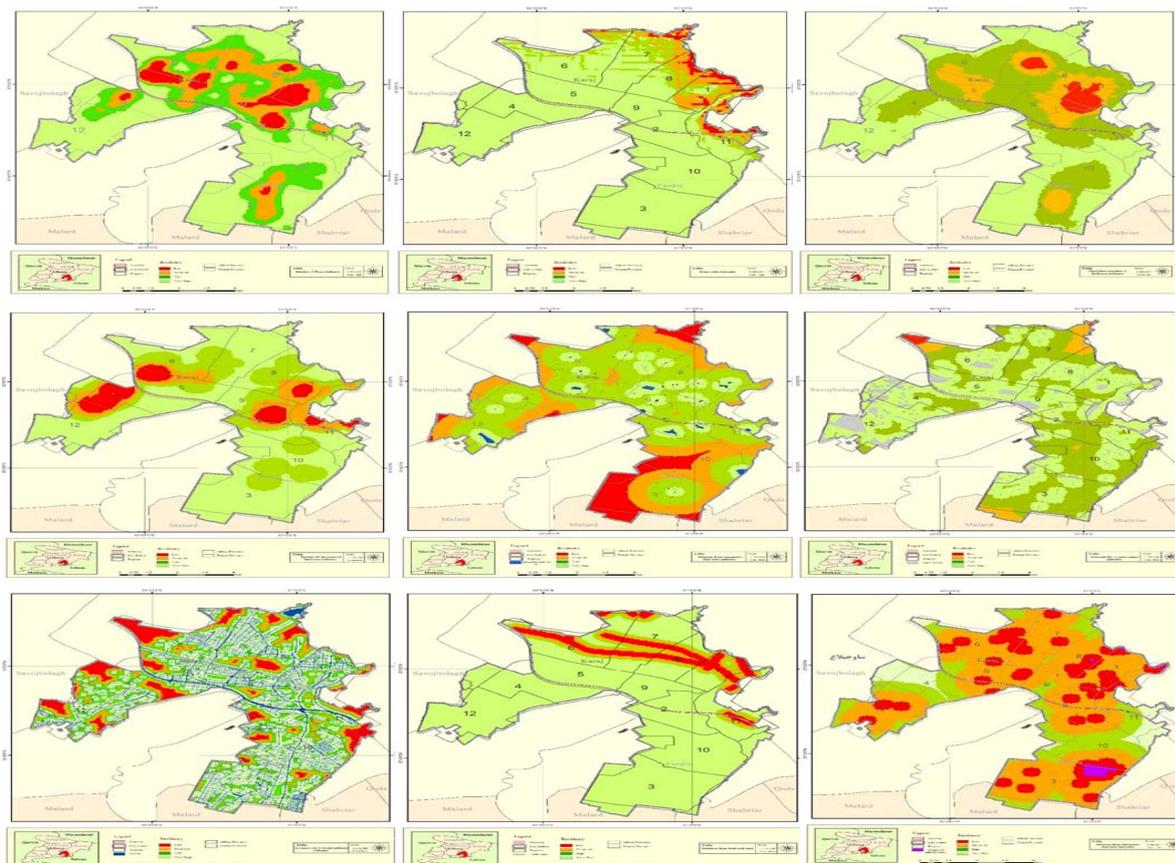
Fig. 4. Various Indicators of Resiliency map in Physico-Structural Dimension of Karaj Metropolis

7. Discussion and Conclusion

Resiliency, has various dimensions and the present study evaluate its physico-structural one. High or low resiliency in one of these dimensions is not a suitable measure for the resiliency of a city.

It is also important to consider and expand the basic question of Carpenter, "resiliency from what to what", for the evaluation of resiliency in a region, city or larger scales. Thus, according to the efforts made for modeling this research with the help of Cutter's disaster resiliency of place model, the research output based on 11 indexes is only one of six final maps used to obtain urban resiliency, in general, and urban resiliency of Karaj, in particular.

The present study in the field of urban resiliency has derived appropriate and independent indexes consistent with the case study and then measured them at the scale of a city. Within the research scope and according to the database available in our country, the present study is completely consistent with reliable studies in the world and tries to clarify various and new aspects of urban resiliency.

At the end, according to the analyses and calculations carried out on the final map of resiliency in physico-structural dimension of Karaj (Figure 5), 5279 out of 17613 hectares of Karaj areas have high resiliency and 6356 hectares have appropriate resiliency; in contrast, 2092 hectares have low resiliency and 3886 hectares have moderate resiliency. So, it can be concluded that over half

of Karaj lands have appropriate and high resiliency in physico-structural dimension. In general, the resiliency of this city is in a desirable situation. Also, districts 1 and 8 in Karaj have the least and districts 12 and 10 have the highest resiliency in physico-structural dimension, respectively. In order to take an action for the improvement of resiliency in some districts of Karaj, it is essential to prioritize the districts as follows: 1, 8, 6, 7, 5, 11, 2, 9, 4, 10, 3, 12. Finally, according to Final evaluation map of urban resiliency of Karaj metropolis, the spatial results may be used by decision-makers and urban managers of each region to enhance level of resiliency.
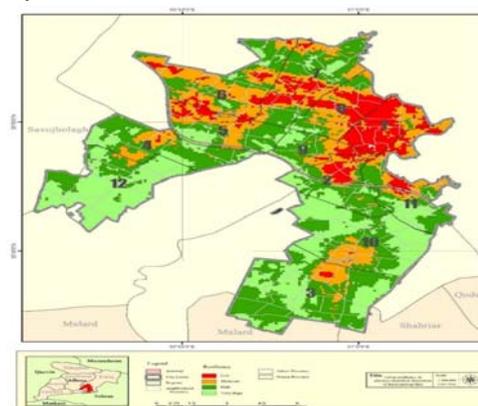

Fig. 5. Final map of Urban Resiliency in Physico-Structural Dimension of Karaj Metropolis

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