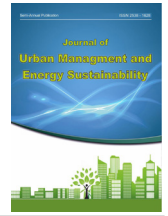


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## ORIGINAL RESEARCH PAPER

### Explaining the model of physical resilience indices in approach to the urban form

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#### ABSTRACT

Urban resilience is the concept of the capacities of urban areas to recognize the priority of resource mobilization in order to eliminate threats and the effects caused by external threats and for stability in temporal and spatial scales when faced with disturbances, to quickly recover their functions in order to adapt to changes but in physical aspect of it, the main concept is urban form resiliency. The main aim of the research is to express the model of the suggested indicators of urban physical resilience on a local scale to be a basic model of evaluation methods in Iran cities. The current research method is analytical-descriptive, and the objective type is practical. The method of collecting information was based on library studies and field observations. First, the basic concepts such as resiliency, urban resiliency at the scale of urban form were investigated and the research framework was extracted. After that, based on the number of factors extracted from the theoretical framework, using the fuzzy Delphi method, the factors were digitally determined by the questionnaire technique from 16 elites and experts in the research field in 3 rounds, and finally the final indexes. The results show indexes of urban infrastructure, urban environment and transportation have the highest score and as a result, the most impact in realizing the construction and practical model. In future, study the relationship of indexes as variation can be evaluated in approach to sustainability.

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## INTRODUCTION

Over the past few decades, unprecedented urbanization has occurred worldwide and cities are under increasing pressure (Ribeiro & Gonçalves, 2019). Today's cities, in the course of the urban revolution, are faced with fundamental challenges in their formal structures, so that after the introduction of modernism, the urban tissues that had an organic organization and at the same time a coherent network, have suffered disintegration in all their dimensions. (Pelling, 2003) The ever-increasing urban population and the resulting haze, traffic congestion, lack of resources and other problems have put great pressure on cities (Huang & Wang, 2020; Andronie et al. 2021), improving urban resilience has become a global consensus to achieve sustainable urban development (Zhang & He, 2020). Initiatives and programs in the field of urban resilience have been created by various organizations, such as the 100 Resilient Cities launched by the Rockefeller Foundation, the 2030 Sustainable Development Goals (SDGs) issued by the United Nations, and the "Resilient Cities" agenda presented at the United Nations Habitat Conference (Colding and Barthel. 2017; Acuti et al. 2020). Cities around the world have already started concrete efforts to improve urban resilience. The Melbourne government published the Resilient Melbourne Strategy (RMS) in June 2016, which included goals, action areas, principles and project plans to improve urban resilience (Datola et al. 2022). The city of Seoul launched the "One Less Nuclear Power Plant" policy in April 2012 with the aim of improving urban resilience through progressive governance (Cho, 2020). The New York City Panel on Climate Change (NPCC) developed a comprehensive plan to reduce future climate risks in coastal areas after Hurricane Sandy (Amirzadeh et al., 2022). As the world's largest developing country, China has experienced the world's largest and fastest urbanization process since its reform and opening up, and its urban resilience is in urgent need of improvement (Amirzadeh and Barakpour, 2021).

The high concentration of urban activities and the invasion of natural disasters put great pressure on Chinese cities (Kumar et al. 2020) Resilience in its macro concept presents a set of concepts in an intellectual paradigm that mostly tries to predict and examine the principles and solutions to minimize these changes. Slow down and remain in the same state as before, or it explains the level of the system's ability to self-organize and the level of the system's ability to create and increase the capacity to learn and adapt (Folke et al. 2011). Despite different applications in different disciplines, urban resilience does not have a universally accepted definition and there are many theoretical interpretations of this concept (LopezDeAsiain, and Díaz-García, 2020). Therefore, resilience remains an ambiguous concept (Alexander, 2013). In addition, most studies use general, vague, and confusing terms. Thus, the term "resilience" has been the subject of much debate (Pirlone, 2020; Wubneh, 2021; Rose and Karausmann 2013; Davoudi et al., 2013). Many consider resilience to be an asset, a process, a state or quality in various domains and at multiple, global, national and local scales. Sometimes the focus is about the resilience of individuals, and sometimes the resilience of different urban, social, economic, political and natural systems is taken into consideration (Fabbri et al. 2020; Wilson, 2013; Benito et al. 2020). The concept of urban form in the morphological view of the urban fabrics that form these cores can analyze the best manifestation of resilience and explain the multiple dimensions of resilience in the functional dimension, which, by nature, extracting the model of this type of approach to the subject of its historical context requires a deep understanding. It is from our mechanism and relationships between the criteria of these dimensions. So that dimensions such as social and economic traditionally in relation to residential areas with institutional and physical dimensions should be presented as spatial and functional relationships are raised.

## **MATERIALS AND METHODS**

### *Methodology*

The current research method is analytical-descriptive, and the objective type is practical. The method of collecting information was based on library studies and field observations. First, the basic concepts such as resiliency, urban resiliency at the scale of urban form were investigated and the research framework was extracted. After that, based on the number of factors extracted from the theoretical framework, using the fuzzy Delphi method, the factors were digitally determined by the questionnaire technique from 16 elites and experts in the research field in 3 rounds, and finally the final indexes were explained. The type of quantitative and qualitative indicators based on the presented model can be evaluated at the sample as a test. After all, the proposed model will present as a main conceptual model of indexes to apply for evaluation urban resiliency in approach to formal dimension of the city.

### *The concept of resilience*

The concept of resilience was proposed by Halling in 1973 in the field of ecology (Zhang & Li, 2018). Resilience in the dictionary is translated as ability, recovery, quick recovery, change, elastic buoyancy, as well as spring and elasticity properties. In the Oxford culture, resilience is defined as the ability of people or things to quickly recover feeling better, aftershocks and misfortunes, and to return to the original state after being bent, stretched or compressed (Oxford, 2022). The word resilience is derived from the Latin word “resilio”, facing back; There is a difference of opinion about the origin of this word, some consider it from ecology (Bruzzone et al. 2021), others from physics. Theoretical studies state that the study of resilience was derived from the methods of psychology and psychiatry in the 1940s, most of which were developed by Norman Gramsci, Amy Werner, and Roth Smith (Zhou, 2009: 22). The first use of the word resilience of engineering was in 1858, by William Color, a Scottish engineer, to describe

the strength and softness of steel axles. It was also used to mean resistance to the effects of earthquakes in the reconstruction of Shimoda after the 1854 earthquake. In 1973, the term was renewed by linking it to systems theory to analyze the reliability of ecological collections. Later, in the work of economists such as Battabial 1998, geographers such as Adger 2002, in the late 1990s, the path changed from natural ecology to human ecology (Alexander, 2013). In the field of ecology, this word became popular after the publication of the main work of Halling called Resilience and Sustainability of Ecological Systems in 1973 (Blaikie, 1997). Halling, in the comparison between the resilience and stability of environmental systems, introduces the system under the influence of external changes and facing unexpected issues, and therefore the importance of the reliability of its internal relationships is greater than the stability of its behavior, and resilience is the ability to return to the balance of the system. , after a temporary disturbance (Gross, 2008). At this stage, the faster the return to balance and the lower the fluctuations, the more stable the system is. Many meanings are used, such as jumping, adapting, overcoming and maintaining strength. Resilience as a concept is promising because it encourages the researcher to bridge the gap between dynamic adaptation and static resistance (Alexander 2013). Resilience is looking for ways to manage in an unbalanced society (Chelleri and Baravikova, 2021). Resilience can be both a normative concept and a descriptive concept (SPeranza et al 2014). Currently, there are several definitions of this term, and today resilience is proposed as a way to strengthen societies by using their capacities (Kärrholm et al. 2014). In the 1990s and two decades after the first mention of resilience, this term was introduced in the urban planning and still with the passage of time, urban resilience lacks a clear definition and in the face of all the crises that the city faces, including economic changes, Globalization, technological, and cultural are discussed (Lu & Stead, 2013). It should be pointed out that like other concepts of urban

planning and crisis management, the concept of resilience also has many dimensions and so far no accepted common definition of it has been presented (Kumar et al. 2020) nevertheless urban resilience means the ability and standing of the city or urban system in Against the stresses and shocks and in relation to man-made urban environments that can function stably in complex, complicated and unpredictable conditions and stand against problems (Han et al., 2021). Also, according to the International Council of Local Environmental Plans, a resilient city is a city that supports the improvement of resilience in its infrastructure and social and economic life. These cities reduce the level of vulnerability and react to economic, social and environmental changes. Provide creative solutions to increase long-term sustainability (Marin, 2021). Cities are subject to gradual and sudden changes. Early diagnosis of these changes and their effects on the city and design and planning based on this diagnosis can significantly improve the resilience of the city against changes (Desouza & Flanery, 2013). Resilience, on the one hand, defines the system that must be resilient, and on the other hand, the type of crisis that the system must be resilient against, and accordingly, it has physical, social, institutional, livelihood, spatial dimensions, etc. (Bruzzone et al. 2021). Resilience has a capacity that can be included in the natural disaster management cycle, before, during and after the disaster (Ndersen & Cardona, 2013). Resilient cities benefit from the positive and negative results of changes (Ozel & Mecca, 2014). Folke does not always consider resilience to be a return to the past and balance, but also the possibility of adaptation and transformation in the existing situation and the possibility of survival and changes in the future (Folke, et al., 2010). According to Carpenter (2012), resilience is the capacity of an ecological and social system to absorb disturbance, reorganize, and thus sustain consequences (Carpenter, et al., 2012). According to the definition of the International Association of Environmental Projects, resilience is the capacity and ability of a society to resist

stress, survive, adapt and bounce back from a crisis and disaster (Stumpp, 2013). Evans (2011) introduces resilience as a goal that is caused by climate change and is a process to adapt to crisis conditions and return to the previous situation, and he considers the best way to achieve it is experience, and from Rose and Krasman's point of view, the complexity of the mechanism and the inconsistency of regions and countries make it very difficult to define a single term, specify indicators and measure them (Rose & Krausmann, 2013). Resilience may be presented as a function of development and environmental changes and the individual's interaction with these changes over time (Ciumasu, 2022). Resilience between the dimensions and indicators of resilience, you can compare the areas and identify those that need resilience. Of course, according to Constes and Brett (2013), the basis of the degree of resilience of societies cannot be measured directly, for this reason, there is a need to create indicators that we specify according to the case under study (Bene, 2013:7). A variety of factors are defined and used globally for resilience, and little research is being done to determine these indicators regularly (Berke & Glavovic, 2022:188). The criteria representing these indicators are: trust or credibility, leadership, collective efficiency, collective capital, social cohesion and sense, social participation, standards, attitudes, existing values, and communication and information (Ndersen and Cardona, 2021:29).

Urban resilience refers to the ability of an urban system and its constituent networks, including socio-ecological and socio-technical networks, for stability in temporal and spatial scales when faced with disturbances, to quickly recover their functions in order to adapt to changes as well as change. The state of the system is fast due to the limits of its present and future adaptive capacity (Meerow et al. 2019). Also, urban resilience is the concept of the capacities of urban areas to recognize the priority of resource mobilization in order to eliminate threats and the effects caused by external threats (Walker and Salt, 2006). In fact, it can be said that a resilient city is

a stable network of physical systems and human societies. Physical systems are the components of the natural and built environment of the city. They include streets, buildings, infrastructure, communities and energy equipment such as waterways, soils, geological slopes and other natural systems. In sum, physical systems act like the body of a city. Bones, veins, and muscles. During a disaster, physical systems must be able to survive and function under the worst stresses. If most of them are damaged and destroyed, the system cannot be repaired, the skeleton is lost. Goes and improvement is done slowly, a city without resilient physical systems will be highly vulnerable to disasters. (Ribeiro et al, 2019) In cities that have high resilience, the number of accidents caused by natural and human disasters reaches its lowest level; Because in cities with high resilience, urban infrastructure with proper rules provides the ground to prevent the construction of buildings in flood plains and sloping lands (Datola et al. 2022). In this way, a resilient city consists of systems that can reduce or neutralize damages, events, and disturbances by considering their measures, and the urban system is designed in such a way that it has the ability to recover and respond quickly to such damages (Han et al., 2021) In general, the concept of resilient city can be considered relative. All cities are changing, but some changes occur gradually and some suddenly, early detection of changes and their effects on the city and planning and design based on this diagnosis can significantly improve the resilience of the city against changes. Cities through their elements, programs and residents can influence the effects of changes. People, as the main part of the city, play an essential role in facing changes. You will suffer less destruction in dealing with accidents (Marin, 2021).

#### *Dimensions of resilience*

Despite the lack of codified framework and indicators, it is only based on the theoretical consensus of the scientific community, resilience is a multifaceted concept with social, economic, institutional and physical dimensions (Rezaei et al., 2014).

- The social dimension is obtained from the difference in social capacity among societies and expresses the capacity of social groups and societies in the process of returning to the initial state or giving a positive response to them. Important and useful concepts of this field are major forms of capital, especially social capital in the fields of risk and disaster. Social capital indicates the quantity and quality of social cooperation in the field of community resilience (Mayunga, 2007). Among the types of capital, social capital, which determines the role and involvement of community members in a way of neighborhood bonds, trust and social institutions directly in risk reduction programs, will be very important and vital.
- The economic dimension, in economics, resilience is defined as the inherent response and adaptation of individuals and societies to risks in a way that enables them to reduce potential losses caused by risks (Rose, 2005).
- Institutional dimension, which contains features related to risk reduction, planning and experience of previous disasters. Here, resilience is influenced by the capacity of communities to reduce risk, the employment of local people in risk reduction, the creation of organizational links and the improvement and protection of social systems in a community, so that at the local level, institutional resilience can be the city of the people of the society should be explained from the state of the institution to the group (Norris, 2008).
- The physical-environmental (infrastructural) dimension, fundamentally evaluates the community's reaction and recovery capacity after the disaster, such as shelters, vacant or rented residential units, and health facilities; Also, these indicators provide a general assessment of the amount of private property that may be particularly vulnerable to permanent damage and possible economic losses. One of the most important vulnerable infrastructures is low-durable houses that are sensitive to a catastrophic event (Rezaei, 2014).

### Resilient urban form

Resilient city form, in terms of density, in two static and normative states; It includes a variety of building typologies based on strong and coordinated infrastructure, multipurpose adaptation or flexible open space (Jenks et al. 1996) (Bramely et al. 2006) (Williams et al. 2000). These are variously expressed as properties that favor the conditions for resilience and are usually defined in terms of climate and environmental changes. In this context, density is the most influential factor on resilience, and its positive form is less energy consumption and greenhouse gas emissions, the result of less need for trips that lead to pollution, reducing pressure on green areas and optimal use of efficient technology in Cooperation with dense urban form causes (Jones & MacDonald, 2004) and creates the ability to resist the predicted effects of climate change in the city and natural environment. In addition, increased residential density is usually associated with increased public transportation, safety, services, and employment, which can contribute to social, economic, and environmental resilience in various ways. The tendency to reduce the definitions of resilient urban form is related to the strong conceptual relationship between the dense city paradigm of sustainable development and perceptions of urban resilience in urban planning and design. For example, Borten (2000) points out the potential hidden costs in environmental sustainability of the dense urban form, which include compression of public and private space and inflation of land values (Dempsey et al. 2010). It should be noted that, while density may appear as a space-based objective, measuring the number of residents in a specific area is subjectively evaluated and a social interpretation dependent on individual characteristics. Jones and MacDonald (2004) argue that if change is considered in conditions more diverse than climate and environment, for example, social, political and economic change – and then a number of other aspects of urban form, from Including building type, street lay-

out, configuration of open spaces, land distribution and transportation infrastructure, property value may be important for building resilience to change. According to these definitions and interpretations, resilience with physical, social, economic and urban environment dimensions can be examined focused on the principle of urban form. Therefore, according to the theories of Burton (2000), MacDonald and Jones (2004) and Smith (2016), the theoretical framework can be expressed according to the following dimensions in the matter of urban form resilience, which in the physical dimension; The population and density of the built form over time and the compatibility of street designs and building types, in the dimension of the urban environment; access to public transportation and access to green spaces and preservation of open land, in the social dimension, the degree of land use and diversity of ownership, and finally the economic dimension; He explained the value of the property in the city. (Figure 1)

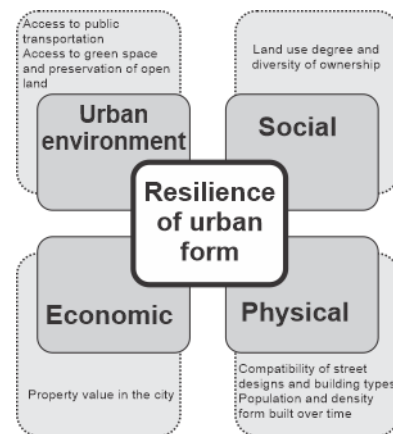


Figure 1: Four dimensions in the conceptual framework of urban form resilience

Therefore, based on the mentioned concepts, in order to achieve the appropriate method for evaluating the resilience of the urban form, a conceptual model can be presented, which is more by examining flexibility in dimensions; Physically in criteria such as population, density and compatibility, environment, in access, social and economic criteria respectively, the degree of

land use and diversity of residence and property value have been explained, and the sustainability approach has been taken into account in the interpretation of the flexibility of the urban form. (Figure 2)

*Resilience indicators*

Resilience may be presented as a function of development and environmental changes and the individual’s interaction with these changes over time. By comparing the dimensions and indicators of resilience, it is possible to compare the regions and identify those that need resilience. Of course, according to Constes and Brett (2013), the basis of the degree of resilience of societies cannot be measured directly, so there

is a need to create indicators that we specify according to the case under study (Bahadur, 2015). Various indicators are defined and used globally for resilience, and little research is being done on determining these indicators regularly (Berke & Glavovic, 2012). The criteria representing these indicators are: trust or credibility, leadership, collective efficiency, collective capital, cohesion and social sense, social participation, standards, attitudes, existing values, and communication and information (Spaans and Waterhout, 2017). The study has extracted the opinion of scholars on urban resilience concepts. The sources and key opinions have been summarized and presented in Table 3.

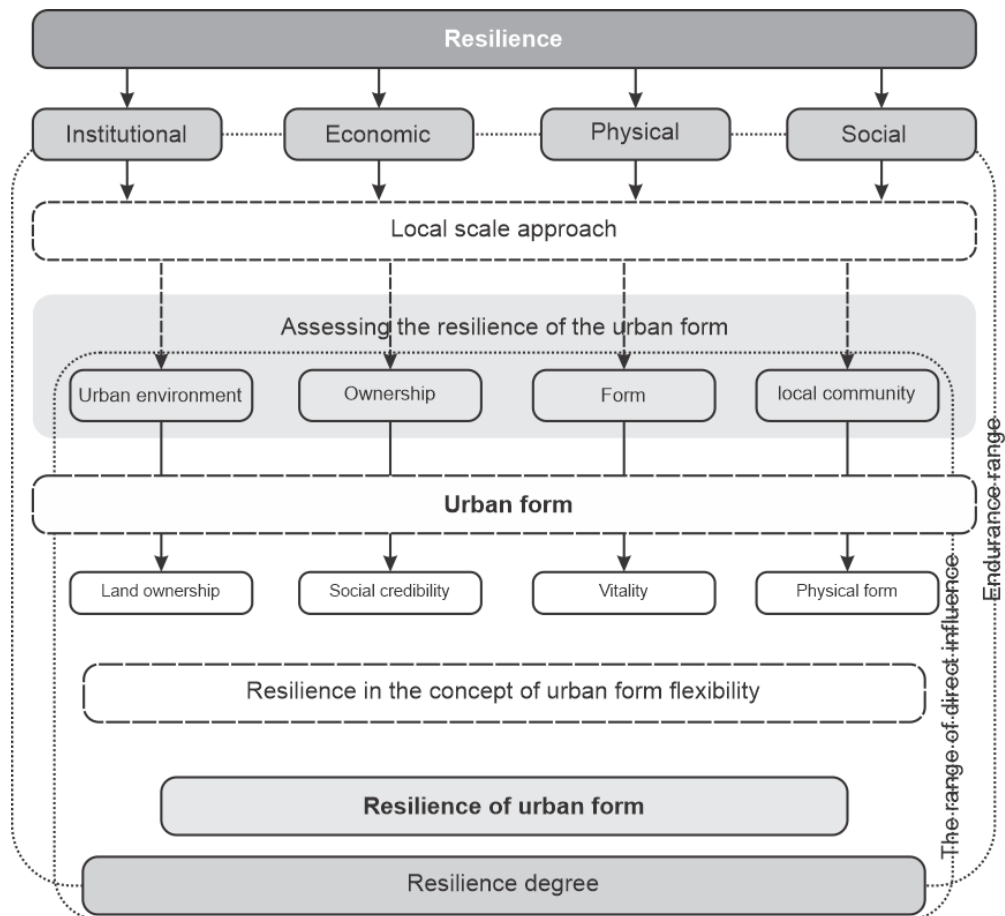


Figure 2: Conceptual model of urban form resilience assessment research

**Figure 3:** The theoretical framework of the concept of urban resilience

Name	Year	Definition
Wubneh	2021	The ability of an urban system to adapt and fully operate in order to maintain its shape, structure, and identity in the face of adversity is referred to as urban resilience.
Bruzzo et al.	2021	An urban resilient community is capable of managing unforeseen events and coping with the pressures and shocks while preserving and developing its social, economic, and infrastructure systems.
McGill	2020	The ability of an urban area to withstand disruption and restore its conditions after a disturbance is known as urban resilience.
Meerow and Newell	2019	Urban resilience as a border entity and the capacity of individuals, families, organizations, industries, and structures within a city's ability to thrive, adapt, and evolve regardless of the types of chronic stresses and acute shocks they face.
Zhang and Li	2018	Urban resilience refers to an urban actor's ability to cope with or respond to hazard stress. Resistance refers to an individual's or a group's ability to withstand the effects of a threat in terms of their economic, psychological, and physical well-being, as well as their maintenance systems.
HN-Habitat	2017	'Resilience is viewed as a process, a state, and a quality.'
Bahadur and Thornton	2015	For urban resilience, decentralized decision-making, systematic learning, interacting concurrently with numerous shocks and pressures, proper urban planning, and recognition of the political underpinnings of risk and vulnerability are all required.
ADB	2014	The ability of a city to function so that its citizens and workers, particularly the poor and vulnerable, may survive and develop regardless of the stressors or shocks they confront is referred to as urban resilience.
Wilson	2013	Community resilience is both an outcome, especially when it comes to communities' better adaptive capacity, and a process or pathway linked to dynamic changes through time associated with community learning and community's determination to take charge of their own development paths.
Wagner and Breil	2013	"The general capacity and ability of a community to withstand stress, survive, adapt and bounce back from a crisis or disaster and rapidly move on".
Thornbush et al.	2013	"A general quality of the city's social, economic, and natural systems to be sufficiently future-proof".
Lu and Stead	2013	"The ability of a city to absorb disturbance while maintaining its functions and structures".
Desouza and Flanery	2013	"Ability to absorb, adapt and respond to changes in urban systems".
Coaffee	2013	"The capacity to withstand and rebound from disruptive challenges".
Wamsler et al.	2013	"A disaster-resilient city can be understood as a city that has managed to: (a) reduce or avoid current and future hazards; (b) reduce current and future susceptibility to hazards; (c) establish functioning mechanisms and structures for disaster response; (d) establish functioning mechanisms and structures for disaster recovery".
Henstra	2012	"A climate-resilient city can withstand climate change stresses, to respond effectively to climate-related hazards, and to recover quickly from residual negative impacts".
Liao	2012	"The capacity of the city to tolerate flooding and to reorganize should physical damage and socio-economic disruption occur, so as to prevent deaths and injuries and maintain current socio-economic identity".
Tyler and Moench	2012	"Encourages practitioners to consider innovation and change to aid recovery from stresses and shocks that may or may not be predictable".



Name	Year	Definition
Romero-Lankao and Gnatz	2011	"A capacity of urban populations and systems to endure a wide array of hazards and stresses".
Leichenko	2011	"The ability to withstand a wide array of shocks and stresses".
Ernstson et al.	2010	"To sustain a certain dynamic regime, urban governance also needs to build transformative capacity to face uncertainty and change".
Wardekker et al.	2010	"A system that can tolerate disturbances (events and trends) through characteristics or measures that limit their impact, by reducing or counteracting the damage and disruption, and allow the system to respond, recover, and adapt quickly to such disturbances".
Lamond and Proverbs	2009	"Encompasses the idea that towns and cities should be able to recover quickly from major and minor disasters".
Alberti et al.	2008	The degree to which cities accept the change before reorganizing around a new set of structures and processes is resilience.
IPCC	2007	Resilience refers to a social or ecological system's potential to absorb perturbations while keeping its essential structure and modes of operation and its capacity for self-organization and adaptation to stress and change.
Campanella	2006	Resilience is a city's capacity to recover from disaster.
Pickett et al.	2004	Resilience is a system's capacity to adapt to changing situations.
Godschalk	2003	Resilience is a linkage of physical systems and human societies that is self-sustaining.

**DISCUSSION AND FINDINGS**

Based on this, the number of factors affecting the issue of physical resiliency in urban form in can be stated as follows according to the type of case includes green space, transportation, variety, climate, urban environment, urban infrastructure, accessibility, urban economy, livability, social diversity, livability, health, urban services, urban management, urban planning.

*Delphi method applies*

In this research, first, the initial model is developed based on the theoretical foundations and the use of existing models around the concepts of the physical resiliency as well as the structural factors in urban form. After the initial design, this model was tested and developed through the Delphi method. The use of open-ended questions in the Delphi questionnaire and their analysis in the next stages was the judgment of reaching a consensus among the experts and reaching theoretical saturation of the qualita-

tive methods used in the analysis of the data obtained in the present research. The collection of field data in the current research started with the collection of questionnaires in the first stage of the research and the extracted data were analyzed through descriptive statistics and qualitative analysis. In this research, urban resiliency dimensions and urban form components are used as a default in the first stage, extracted from the theoretical foundations of the subject, and then the resiliency dimensions and its factors are presented according to the research hypothesis. These factors have been expressed based on the estimation of the awareness dimension of specialists and also the perceptual process of citizenship with consideration. These factors are set as a package of suggestions in the panel of experts and elites so that the Delphi method can be planned and applied. A total of 15 factors that were tested with this method to reach the final indexes.

Figure 4: Dimensions and factors of urban resilience

Dimensions of urban resilience	Resilience factors	References
Social	Equal access to community resources Citizen engagement in policy process Community cooperatives/club Collaboration of multi-stakeholder Community support Social networks Training Education, Knowledge, Skill Health Accommodation Adaptive capacity Vulnerability of household and population health. Cultural services Reducing violence, insecurity and urban crime Learning capacity and awareness, Diversity of social classes Creativity and innovation, expertise and ability human resources Timely response speed, Social capital	Hassler et al, 2014 Godschalk, 2012 Walker et al. 2006 Sarker et al. 2020 Ribeiro and Gonçalves, 2019 Frantzeskaki et al. 2019 Kim & Lim, 2016 Godschalk, 2012 Chelleri and Baravikova, 2021 Heinzlef and Serre, 2020 Fang et al. 2016 Ciumasu, 2018 Sharifi et al. 2017 Carter et al. 2015 Bahadur and Tanner, 2014 Ribeiro and Gonçalves, 2019
Economic	Inclusive access to credit and market Access to ICT and technology Livelihood and livability Urban economy strategies and policies wealth and employment Economic diversity	Eraydin & Tasan-Kok, 2012 Ernstson, et al. 2010
Physical	Urban green space Access to transport Variety Climate and soil health Adaptive design (urban environment quality index through the role of space design and organization) Urban infrastructure of ecosystem services (modular) Quantitative-ness and measurability The resistance strength of the physical elements and components of the city, such as roads and buildings, Adaptability or redundancy capacity, Stability, Natural capital	Walker & Salt, 2006 Godschalk, 2012 The Rockefeller Foundation et al. 2016 Folke, 2016 Feliciotti et al. 2016 Moench, 2014 Chelleri et al. 2021 Cobbinah, 2021 Meerow and Stults, 2016 Leitner et al. 2018 Davoudi et al. 2013
Institutional	Emergency services of government Community-oriented urban planning Monitoring expenses Human resources and equipment Quality Quality assurance Safety promotion Shared facilities of natural resources Inclusive governance for sharing benefits Coordination of works of multi-stakeholder Communication technology Planning and framework development United command development Determine ahead for each task Early warning system Protective infrastructure Govern credit and resource distribution Human resource usage, Strengthen coverage of disaster management Utilization of equipment, Access to legal and policy system Institutional skills and structures Decision-making and decision-making policies Integrated Management Diversity of organizational levels and inter-organizational communication Adaptive capacity Timely response speed	Ernstson, et al, 2010 Colding and Barthel, 2013 Suárez et al, 2016 Malone, 2019 Panampitiya, 2021 McGill, 2020 Davoudi et al. 2013 Ernstson et al. 2010 Ribeiro and Gonçalves, 2019 Brown et al. 2012 Molavi, 2018 Meerow and Newell, 2019 Reischl et al. 2018 Nagenborg, 2019 Moench. 2014 Chelleri et al. 2015 Cobbinah, 2021 Sarker et al, 2020

*Findings of implementing the Delphi method*  
*First round*

In this round, the panel members identified 11 factors out of 15 factors that were extracted from successful research as having moderate, high, and very high influence in developing a resiliency in urban form framework based systematical concept. The detailed and extended results related to the implementation of the first stage of questionnaire distribution are given in the following table. Factors of variety, climate, livability and health have been removed from the Delphi process due to their average importance of less than 2.5. (Tab.2)

After the implementation of the first stage of assessment and evaluation of the opinion of the experts of the panel regarding the factors proposed and extracted from the theoretical bases and also receiving the suggestions of the panel members, in this round, to observe caution, all the factors extracted from the theoretical bases are again together with the average opinion of the members in the first round and the previous opinion of the same member, it was provided to all the experts of the panel. The panel members recognized 9 factors out of the 11 factors that were presented in the second round as having a high and very high impact (with an average greater than 3.5) on the research framework. The detailed and extended results related to

the implementation of the second stage of questionnaire distribution are given in the table below. Kendall's coordination coefficient for the answers of the members of the order of the 9 factors that had a high and very high influence in this round was 0.775. (Tab. 3)

*Third round*

In the third round of compiling the research framework, the final indicators, along with the average opinion of the members in the second round and the previous opinion of the same member, were provided to all panel experts. The detailed and extended results related to the implementation of the third stage of questionnaire distribution are given in the table below. Kendall's correlation coefficient for the members' answers about the order of the 8 factors was 0.789 (Tab. 4).

*Reasons for stopping polling*

The results of the three rounds of implementing the Delphi method in the research show that a consensus has been reached among the panel members for the following reasons and the repetition of the rounds can be ended:

- 1- In the second round, more than 50% of the members chose 11 influential factors in physical resiliency in urban form up the case study, who had an average greater than 3 among their factors.

**Table 2:** Phase one of the model of physical resilience indices in approach to the urban form

No.	Factors	Response	Average	Standard Deviation	Min.	Max.
1	green space	16	3/20	0/40	1	5
2	transportation	16	3/15	0/55	1	5
3	urban environment	16	3/15	0/35	1	5
4	urban infrastructure	16	2/90	0/29	1	5
5	accessibility	16	3/78	0/50	1	5
6	urban economy	16	3/62	0/42	1	5
7	livability	16	3/08	0/48	1	5
8	social diversity	16	3/90	0/28	1	5
9	urban services	16	3/32	0/20	1	5
10	urban management	16	3/35	0/62	1	5
11	urban planning	16	3/45	0/40	1	5

- 2- The standard deviation of the members' answers about the importance of the factors in the third round has changed significantly compared to the previous rounds.
- 3- Kendall's coordination coefficient for members' answers about the order of factors in the third round is 0.789. Considering that the number of panel members was more than 10 people, this amount of Kendall's coefficient is considered quite significant.
- 4- Kendall's coordination coefficient for the arrangement of the 8 influential factors in developing the research framework in the third round compared to the second round only increased by 0.025, which indicates a significant growth in this coefficient or the degree of consensus among the panel members in two consecutive rounds. Does not show
- 5- The points given to the factors by the experts and elites indicate that the characteristic indexes of urban infrastructure, urban environment and transportation have the highest score and as a result, the most impact in realizing the construction and working model.

**Table 3:** Phase two of the model of physical resilience indices in approach to the urban form

No.	Factors	Response	Average	Standard Deviation	Min.	Max.
1	green space	16	3/65	0/40	2	5
2	transportation	16	3/95	0/45	2	5
3	urban environment	16	3/90	0/35	2	5
4	urban infrastructure	16	3/65	0/25	2	5
5	accessibility	16	3/95	0/45	2	5
6	urban economy	16	3/65	0/35	2	5
7	urban services	16	3/75	0/20	2	5
8	urban management	16	3/45	0/42	2	5
9	Social diversity	16	3/95	0/42	2	5

**Table 4:** Phase three of the model of physical resilience indices in approach to the urban form

No.	Factors	Response	Average	Standard Deviation	Min.	Max.
1	transportation	16	4/60	0/30	3	5
2	urban environment	16	4/65	0/35	3	5
3	urban infrastructure	16	4/80	0/25	3	5
4	accessibility	16	4/60	0/22	3	5
5	urban economy	16	4/25	0/15	3	5
6	urban services	16	4/22	0/20	3	5
7	urban management	16	4/05	0/24	3	5
8	Social diversity	16	4/20	0/25	3	5

**RESULT AND CONCLUSION**

*Research model explanation*

Based on this, the following research framework can be presented as the result of studies, theoretical framework, and Delphi method (Tab.5):

Table 5: Proposal research model

The dimensions, indicators, and indexes in the model of physical resilience indices in approach to the urban form			
Dimension	Index	Index type	Measurement
Social	Social diversity	Qualitative	Questionary
Economic	urban economy	Qualitative	Questionary
Physical	accessibility	Qualitative	Questionary
	urban services	Qualitative	Questionary
	transportation	Qualitative	Questionary
	urban environment	Qualitative	Questionary
	urban infrastructure	Qualitative	Questionary
Institutional	urban management	Qualitative	Questionary

Therefore, it can be concluded that the social, economic, physical and non-food dimensions have a direct relationship and impact on the urban system, but in the urban physical aspect, these dimensions can be mentioned in the structure of the urban form. In the topic and concept of resilience of urban form, accessibility index and urban infrastructure have the most influence on the structure of resilience of urban form. In the current situation of Iranian cities, due to the existence of many tissues with urban problems from a physical point of view, there is an urgent need to create a resilient structure. The limited and lack of access and the weakness of the urban infrastructure in the historical contexts as well as the relatively old contexts have caused this part of the city to have a high capacity for destruction and accidents. In future research, these indexes can be evaluated in a case sample.

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