Int. J. Nonlinear Anal. Appl. 15 (2024) 12, 237–245
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2023.32275.4793

Identifying and prioritizing the components of urban intelligence to increase the resilience of cities

Maryam Fathi*, Mojtaba Amiri

Faculty of Management, Tehran University, Tehran, Iran

(Communicated by Ali Gaffari)

Abstract

Nowadays, smart urban management improves the resilience of cities. Since the resilience of a city increases with the smartening of its infrastructures, so it seems that resilience and smart urban management by using common infrastructures and indicators have an effect on solving today's urban problems. They have a lot. Therefore, this study has identified and prioritized the components of urban intelligence to increase the resilience of cities as its main goal. This study is based on practical purpose and in terms of data collection, it is a descriptive correlational type that has used library sources and a questionnaire to collect the required information. The questionnaire of this study is a researcher-made questionnaire and consists of 105 questions whose validity and reliability have been confirmed. The statistical population of this study consists of specialists, experts and experts in the field of urban management in Tehran, of which 168 people were randomly selected as a statistical sample using Cochran's formula. In order to analyze the data, the structural equation method and Lisrel and SPSS software were used, and finally, the identified indicators were prioritized based on the AHP method. The obtained results indicate that the components of urban intelligence for the resilience of cities are under the indicators of building, energy, telecommunications, transportation, human services, water and its treatment, public security and payments. The results of prioritizing the indicators also prove that human services, buildings and transportation systems have a higher priority compared to the size of the indicators and it is necessary to be given special attention by the relevant authorities and experts in order to create resilient smart cities.

Keywords: smart cities, resilience, urban smartness, resilience of cities
2020 MSC: 91D10, 91B82

1 Introduction

Today, with the expansion of the population and the growth of urbanization and the high rate of migration to the center of big cities, urban issues and challenges have also increased and it is clear that the need to control and manage these issues is more visible than ever. According to projections made until 2050, population growth and urbanization will add 2.5 billion people to the world's urban population [9]. In such a situation, many problems such as crowding, environmental pollution, problems in waste management, lack of resources, traffic congestion, energy crisis, and inadequate infrastructure remain unsolved and impose many destructive technical, physical, environmental, and social effects on societies [17]. Therefore, creating urban landscapes and environments with optimal performance,

*Corresponding author
Email addresses: maryam.fathi@ut.ac.ir (Maryam Fathi), mamiry@ut.ac.ir (Mojtaba Amiri)

Received: September 2023 *Accepted:* December 2023

safe and sustainable for living and working is important in urban planning [12] and urban smartness is one of the expanding global phenomena in the 21st century, in the direction of Solving the current challenges of urbanization has been marketed [19]. In other words, considering the impact of cities on the sustainability of societies, theories of urban development such as compact city, smart urban growth, electronic city and urban smartness have emerged as a response to inefficient and unstable patterns of urban growth [2]. A smart city with indicators such as smart governance, smart environment, smart economy, smart mobility, smart life and smart people, seeks to achieve urban sustainability, develop network infrastructure, develop entrepreneurship and increase residents' access to public services to promote justice. Social inclusiveness is the development of urban creative industries and the development of social and communication capitals [14]. In urban management theories, realizing smartness is considered as a way to manage increasing pressures such as climate change, urbanization, and population growth [7]. Also, intelligentization is useful for strengthening transparency, analysis and planning, strengthening citizen interaction and participation, supporting innovative products and ideas in providing services, and providing solutions for many social, economic and environmental problems [20]. Meanwhile, cities are always exposed to new risks and damages due to their constant change and dynamics, and they need appropriate methods and models to deal with and manage these accidents. In other words, cities need to reach a resilient level in their different dimensions. In this situation, cities and citizens have the necessary preparation for any challenges and accidents (both natural and human) [18]. Therefore, to prevent the increase in vulnerability, it is necessary to examine the strengths and weaknesses of the city to face accidents to strengthen the resilience of the city. Because identifying the place and the way of influencing and influencing urban intelligence indicators on resilience and identifying key and strategic factors will help the society in planning for resilience. Therefore, in this study, the identification and prioritization of the components of urban smartness to increase the resilience of cities have been explored.

Theoretical foundations and research background

Davoudi [8] introduces the root of resilience from the Latin word res-lire, which means jumping to the past. He believes that resilience was first used by physical scientists to describe the stability of materials and their resistance to external shocks. This is even though in the 1960s and with the emergence of systemic thinking, resilience entered the field of ecology and many meanings were extracted from it according to different scientific perspectives and methods. Since the 1990s, resilience appeared as a concept about cities and planning and in response to environmental threats and the regulation of social and institutional frameworks and gradually entered the discussions and theories of urban planning [15]. The term "resilient" was introduced in the discussion of disaster management at the Hugo Conference in 2005. Gradually, this concept gained a higher position in both the theoretical and practical aspects of reducing the risks of accidents and was raised in different dimensions of resilient society, resilient livelihood, resilient ecosystem, etc. Meanwhile, urban resilience is a relatively new concept in urban studies and urban planning [11].

Resilience in cities is interpreted as one of the types of socio-ecological systems in the following cases. 1- The amount of disturbance that a system can absorb and still remain in the first state. 2- The extent, or the degree to which the system can self-organize in the absence of an organizer applied by external factors. 3- The extent, or the degree to which the system can be built, or its capacity for learning and adaptation (adaptive) can be increased. According to the above, urban resilience is the degree, limit, or amount in which cities can withstand change, before being reorganized into a new set of structures and processes. Resilient societies, like ecosystems, should have the ability to resist disturbances and adapt to changes when they need it [1]. According to Agudelo-Vero and his colleagues [4], urban resilience is defined as the ability and resilience of the city and the urban system against stresses and shocks. Caputo [6] about man-made environments, considers resilient cities to be cities that operate sustainably in complex and unpredictable conditions and are resistant to problems.

Today, many studies have been conducted to understand the features and characteristics of resilience in cities. As an example, Afsari and Hasanalizadeh [3] in a study concluded that the managers and planners of the metropolis of Tehran, for any action to prepare the city to deal with natural and man-made crises, should refer to the indicators of urban resilience with the passive defence approach identified in their study. And it has been explained to pay attention and the basis of all their executive plans and decisions is to improve the mentioned indicators. Ketabchi et al. [16] also stated in their study that the future scenarios for urban resilience such as the Tehran metropolis should be based on key basic factors. Therefore, it can be said that to face the upcoming crises, there is a need for wise and principled guidance and leadership in the development of cities [10]. In this context, Mark Visser believes that the smart city has maximum benefits for citizens and will therefore make cities more sustainable and livable for residents [13]. In his study, Ismailzadeh [14] states that making smart using indicators such as smart environment, smart mobility, smart life, smart governance, smart economy and smart people is an effective approach to achieving sustainability in economic, social, and environmental and They are considered physical. The reviews of Abdul Ahad et al. [5] show that technological interventions in daily processes have led to the emergence of smart ecosystems in which all aspects of daily life such as governance, transportation, agriculture, maintenance, education, healthcare, etc. They are intelligent, controlled and managed. An issue that confirms the instrumental role of the smart city approach in pursuing urban resilience and reveals a new model for sustainable city management and development [21]. In this study, the analysis to identify the compatibility between the resilience and smart city frameworks confirmed the hypothesis that these two frameworks share certain fundamental determinants that allow the development of a single concept rather than two discrete approaches in the field of urban development. Both concepts of urban resilience and smart city serve the purpose of sustainability and share the operational framework of systems thinking. In addition, systemic capacities for adaptation, efficiency, and knowledge creation are common in urban smart and resilience frameworks. However, based on the importance of the technology dimension, the smart city model seems to play a fundamental role in the operationalization of resilience. The smart city has a five-stage procedure consisting of design and planning, simulation and modelling, implementation, technology management and evaluation, which can be the general basis for designing a process for a resilient smart city, and comprehensive crisis management must also necessarily be in five stages. The phases of prevention, risk reduction, preparation, coping reconstruction and rehabilitation should be carried out. However, the research literature has shown that there is a serious lack of studies on both approaches.

Research methodology

This study is based on the purpose of an applied study and in terms of data collection, it is a descriptive correlational type. In terms of collecting field research information (through a questionnaire) and in order to collect information in the field of theoretical foundations and research literature, library sources have been used. The statistical population of this study consists of specialists, experts and experts in the field of urban management of Tehran city, around 300 people were identified. From this number, 168 people were randomly selected as a statistical sample using Cochran's formula.

The collection tool of this study is a researcher-made questionnaire. To verify the validity and reliability of the questionnaire, the opinions of 25 experienced university professors, experts and experts in this field were used and the correction suggestions of this group were applied and the final questionnaire was compiled. Then, by determining the content validity index (CVI) of the final questionnaire, its validity has been approved. Also, with the experimental distribution of the questionnaire in a prototype including 40 questionnaires and using the obtained data and SPSS software, the reliability coefficient was calculated according to Cronbach's alpha coefficient and its reliability was confirmed.

Based on the study of the literature in this field, the questionnaire of this study includes 8 indicators and 105 items, which are introduced in Table No. 1. After collecting information and data (through a questionnaire), structural equation modeling and factor analysis were used to analyze the data, and the data were measured and evaluated based on SPSS and Lisrel software. Finally, in order to prioritize the identified indicators, the AHP method has been used.

2 Research findings

The descriptive findings of this study on the demographic characteristics of the respondents indicate that about 70% of the respondents are men, and among the respondents, the highest percentage is allocated to people with a postgraduate degree with about 50%. 25% of the respondents have a doctorate degree and the rest have a bachelor's degree. Most of the respondents have more than 20 years of work experience and more than 70% of them have experienced management in one of the city departments. In order to identify the components of urban smartness in increasing the resilience of cities, it has been investigated using LESREL software and linear structural relationships and factor analysis. In the investigated model, based on the existing literature, the eight factors of building, energy, telecommunications, transportation, human services, water and its treatment, public security and payments as external latent variables and resilient smart city as internal latent variable in have been considered the variables measured in the questionnaire to estimate each of the above factors are also considered as obvious variables.

Exploratory factor analysis was used to identify the components in the research questionnaire, and first, to check the adequacy of the sample and the reliability of the factor analysis results, the Kaiser-Meier coefficient and Bartlett's test were calculated and it was equal to 0.988. Since this coefficient is higher than 0.6 and significant, it can be said that at the level of alpha error (0.05) the instrument has internal dimensions and it is possible to refer to the results of factor analysis, and therefore all the research questions for the factor analysis test have Credit is required. The output results of Lisrel software for fitting the desired model are shown in Figure 1. It should be noted that three items were not significant in the initial fitting, which were removed from the data and the model was fitted again. Based

Table 1: Indicators of resilient smart cities

object	**Indicator**	**object**	**Indicator**
general health		Energy efficiency in buildings	
Education		Use of renewable resources in buildings	
Child care		Intelligent building systems	
Social service		adaptation to climate change	
Housing		Sustainable building materials	Building
Economic ability		Connecting to urban smart networks	
Crisis management and urban security		Adaptability to cyber attack	
Culture and Art		Intelligent management system	
Electronic services	Human services	Training residents and building staff	
Support for women and gender discrimination		Smart energy networks	
Urban green space		Use of renewable energy sources	
Recreation and sports		Energy consumption management	
Improving air quality		Automation and automation	Energy
Helping the underprivileged		Prediction and management of network load	
Helping immigrants		Development of sustainable public transport	
Pollution and waste management		Electric chargers	
Citizen participation		Citizen participation	
Access to drinking water	Water and its purification	Creating resistance infrastructure	
Effective allocation of water resources		Environmentally friendly energy	
water refinery		Compatibility with old energy networks	
Reduce water waste		Network coverage	
Flood management		Bandwidth	
water quality		Network Security	
High tolerance water supply		Communication standards and protocols	
Water as an energy source		Data forecasting and analysis	
Education and awareness of citizens		traffic management	
Water crisis management		Waste Management	Telecommunications
Legislation and regulations		Security management	
Development of water technology and new springs		Citizen participation	
Crime rate		Funds	
Crisis and emergency management		Sustainable public transport	
public order		Smart transportation network	
Police and security forces		Transportation database	
How to deal with victims of criminal matters		Smart vehicles	
Smart security systems	Public safety	Self-driving	
cybersecurity		Vehicle sharing platforms	
Information security		Traffic and traffic management	
Border control		Smart parking management	
Monitoring of public space		decreasing air pollution	Transportation
Arms control		Intelligent communication between vehicles	
Budget and taxes		Transport network load manager	
City revenues		Participation of citizens in traffic management	
Electronic payment systems		Development of pedestrian and bicycle transportation	
Smart financial platforms		Transportation of cargo and goods	
Debt and receivables management		Resistance ability of transportation systems	
Urban banks	Payments	Financial management of transportation systems	
Investment in public projects			
Environmental tax			
Business support			
Financial crisis management			
Management of national assets			
Social payments			
Financial traffic management			
Marketing and investment attraction			
Arrears tax			
property tax			

Source: researcher's findings

on the final fitting result, it can be said that the factor loadings of all 102 variables are above 0.6, which indicates the desirability of these values. In other words, it can be said that the variables observed in the model can adequately explain the corresponding variable. Figure 2 shows the t-test related to the significance of the factor loadings of the model. This figure also shows the significance of all factor loading coefficients (the observed value is greater than the critical value of the statistic (1.96) t).

In addition to estimating the model's coefficients and errors, Lisrel software provides a series of fit indices as follows, which can be used to test the overall fit of the model. One of the important indices in structural equations is the RMSEA index. Based on the output of Lisrel software (Figures 1 and 2), the RMSEA index is equal to 0.033, which, considering that the value of this index is smaller than 0.1, the fit of the model is appropriate. Also, one of the general indices to take into account the free parameters in the calculation of the fit indices is the normal chi-square index, which is calculated by simply dividing the chi-square by the degree of freedom of the model. Based on the results of the output of the software, this index is 2.51, which is suitable considering that the obtained value is less than 3. Other indicators related to model fit are shown in Table 2. Considering that the value of the mentioned indicators must be in the range (1 to 0) for the model to be in a suitable state, the value of these indicators in this study is a suitable value and therefore the model is acceptable in this sense. Considering that the fit indices of the model indicate the proper fit of the model, it can be concluded that a suitable model has been estimated. Therefore, the fit of the collected data with the model is favorable. Therefore, the suitability of the final model is confirmed.

Table 2: The values of the fit indicators of the model for identifying the indicators of resilient smart cities

amount of	**Indicator**
2.51	(Chi-square on the degree of freedom)
0.033	RMSEA
0.83	CFI
0.85	IFI
0.93	GFI
0.92	AGFI
0.84	NFI
0.91	NNFI

Finally, in order to prioritize the eight indicators of resilient smart cities, the AHP method based on the opinion of experts has been used. These eight factors are such that each index gets a weight compared to the other index, the reverse of which is considered for the second index. The matrix of pairwise comparisons and the normal matrix related to this index are also presented in tables No. 3 and 4. Based on the relative importance coefficient presented in table number 4, human services with a coefficient of 0.197 has been assigned the highest importance among the indicators of resilient smart cities. The building is placed after it with a coefficient of 0.193. Transportation is the third most important. Energy, telecommunications, water, payments and public safety are next.

Table 3: Matrix of paired comparisons of the components of resilient smart cities

Resilient smart cities	**payments**	**public security**	**water and its treatment**	**human services**	**transportation**	**telecommunications**	**energy**	**Building**
Building	3.06	2.99	3.86	0.25	2.00	1.97	2.01	1.00
Energy	2.05	3.00	0.14	0.20	3.00	1.98	1.00	0.50
Telecommunications	3.00	2.00	2.00	0.20	2.00	1.00	0.51	0.51
Transportation	2.00	3.00	2.00	2.00	1.00	0.50	0.33	0.50
Human services	5.00	2.00	2.00	1.00	0.50	2.00	2.00	1.78
Water and its purification	3.00	2.00	1.00	0.50	0.50	0.50	1.87	0.26
Public safety	1.00	1.00	0.50	0.50	0.33	0.50	0.33	0.33
Payments	1.00	1.00	0.50	0.20	0.50	1.00	0.49	0.33

The weighted sum vector (WSV) and the CV compatibility vector related to the indicators of resilient smart cities along with the calculated compatibility rate are presented in Table 5 and show that the compatibility rate of this index

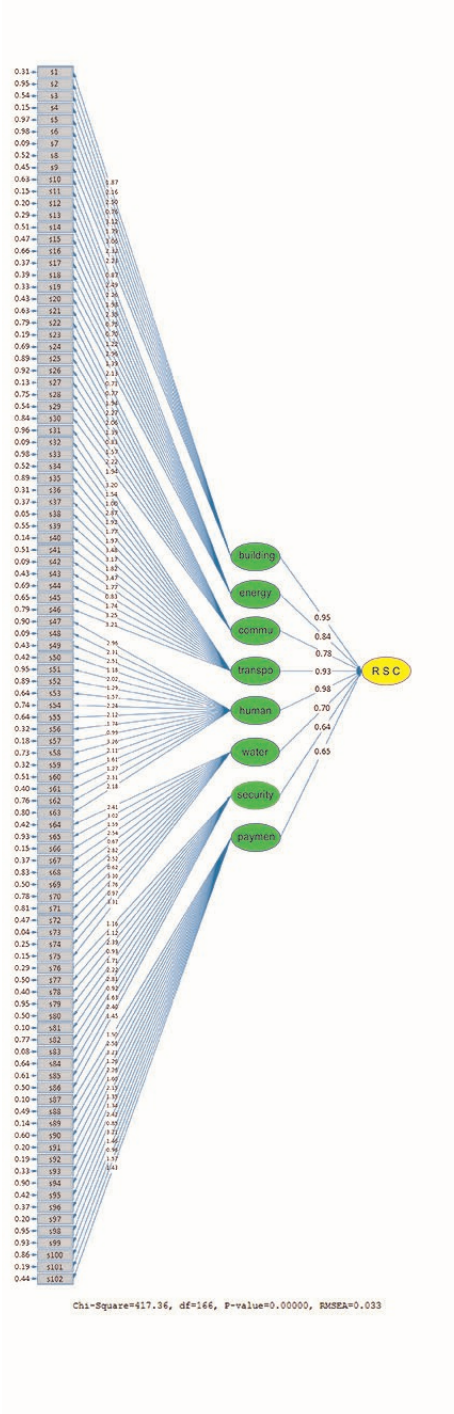

Figure 1: Coefficients of the investigated factors

is equal to 0.095. This issue indicates that because the obtained rate is less than 0.1, therefore, the group matrix of indicators of resilient smart cities is compatible and therefore, the obtained priorities are reliable.

3 Summary and conclusion

Disasters and natural events in recent decades show that today, people and urban communities have become the most vulnerable, and basically, the reduction of vulnerability happens after the occurrence of disasters and accidents. In the meantime, resilience is a concept that is meaningful to face these events. In other words, the resilience approach

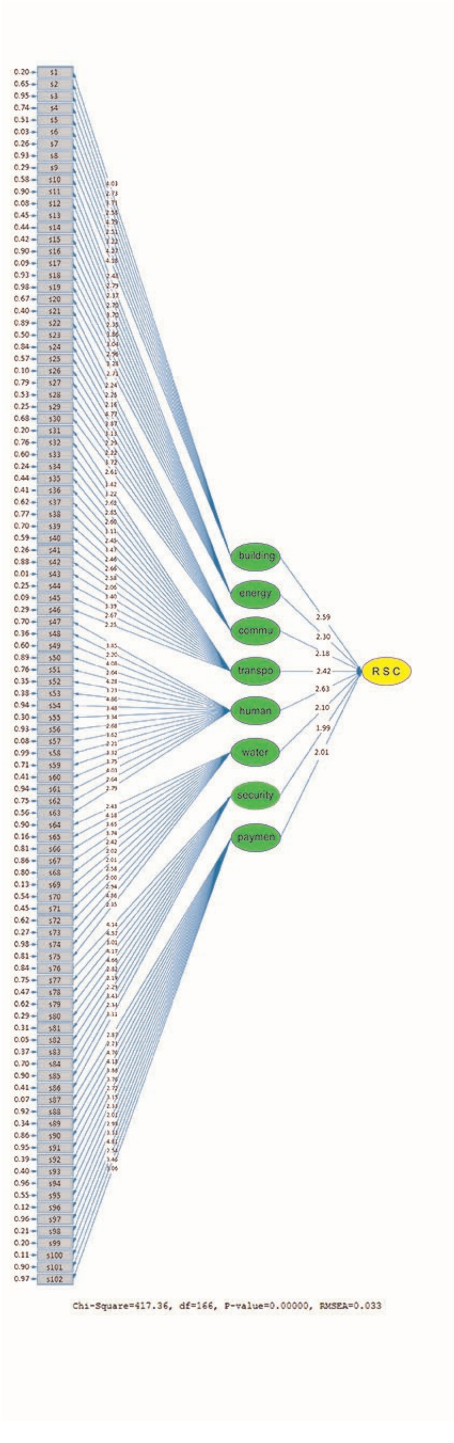

Figure 2: Coefficients of the investigated factors

is used to face problems. Resilient urban design has different dimensions that help to increase resilience. On the other hand, the development of new technologies has exposed cities to huge changes, and today new technologies are flowing in all fields and give citizens more ability to live better. Therefore, in addition to saving money and energy, smart cities should create an attractive and peaceful urban life for citizens. Therefore, it can be said that the requirement of a smart city is integrated and intelligent management of the city, while a resilient city needs the proper management of smart infrastructure, and this is how the infrastructure exists and is managed, which creates resilient smart cities. Comprehensive crisis management must necessarily be carried out in five phases: prevention, risk reduction, preparation, coping, reconstruction, and rehabilitation, which cannot be achieved and implemented without the smartness of urban control and management systems and the absence of smart urban infrastructure. Therefore,

Table 4: Normal matrix of the components of resilient smart cities

Resilient smart cities	payments	public security	water and its treatment	human services	transportation	telecommunications	energy	Building	Resilient smart cities
Building	0.152	0.176	0.322	0.052	0.203	0.208	0.235	0.192	0.193
Energy	0.102	0.17	0.012	0.041	0.305	0.210	0.117	0.096	0.132
Telecommunications	0.149	0.118	0.167	0.041	0.203	0.106	0.059	0.097	0.118
Transportation	0.099	0.177	0.167	0.412	0.102	0.053	0.039	0.096	0.143
Human services	0.249	0.118	0.167	0.206	0.051	0.212	0.234	0.342	0.197
Water and its purification	0.149	0.118	0.083	0.103	0.051	0.053	0.219	0.050	0.103
Public safety	0.050	0.059	0.042	0.103	0.034	0.053	0.039	0.064	0.055
Payments	0.050	0.059	0.042	0.041	0.051	0.106	0.057	0.063	0.059

Table 5: Weighted sum vector (WSV) and CV compatibility vector related to the indicators of resilient smart cities

CV	WSV	Indicators
9.186	1.768	Building
9.297	1.231	Energy
9.361	1.101	Telecommunications
8.572	1.227	Transportation
8.727	1.721	Human services
8.873	0.916	Water and its purification
8.645	0.479	Public safety
8.915	0.522	Payments
87.15	**Total**	
8.94	λ max	
0.135	*I.I*	
0.095	*C.R*	

officials and experts in the field of urban management should follow the strategic path of the city intelligently in order to improve the resilience of the urban structure in times of disaster.

In this study, based on the model fitted by Lisrel software, the eight indicators of building, energy, telecommunications, transportation, human services, water and its purification, public security and payments as components of urban smartness to increase resilience The cities are known. To prioritize the identified indicators, the AHP method was also used and the results indicate that the human services index had a higher priority in the eyes of the respondents. The sub-categories considered in this study for this index are 1. Public health, 2. Education, 3. Child care, 4. Social services, 5. Housing, 6. Economic empowerment, 7. Crisis management and urban security, 8. Culture and art, 9. Electronic services, 10. support for women and gender discrimination, 11. urban green space, 12. recreation and sports, 13. promotion of air quality, 14. assistance To the needy, 15. Assistance to immigrants, 16. Pollution and waste management, 17. Citizen participation.

After that, the building had a higher priority in the eyes of the respondents. The sub-categories considered in this study for this index are: 1. Energy efficiency in buildings, 2. Use of renewable resources in buildings, 3. Intelligent building systems, 4. Adaptation to climate change. 5. Sustainable building materials, 6. Connection to urban smart networks, 7. Compatibility with cyber attack, 8. Intelligent management system, 9. Training of residents and building staff. Urban transportation is ranked third in this respect. Therefore, based on the findings of this study, it is necessary for the relevant experts and officials to pay more attention to the promotion and improvement of the priority sectors, namely human services, buildings and the urban transportation system, in planning and allocating resources, and considering these indicators in order to create Resilient smart cities should try.

References

[1] Y. Abdali, A. Pourahmad, M. Amini, and I. Khandan, *Investigating and comparing the resilience of pre-created and planned communities to reduce the impacts of natural disasters (earthquake) (Case study: Nourabad County and Maskan-e Mehr of Nourabad City)*, Geographic Inf. **28** (2018), no. 110, 147–161.

[2] A. Addas, *The concept of smart cities: A sustainability aspect for future urban development based on different cities*, Front. Envir. Sci. **11** (2023), 1241593.

[3] R. Afsari and M. Hasanalizadeh, *Identifying and explaining urban resilience indicators with a passive defence approach (Case study: Tehran metropolis)*, Human Geography Res. **55** (2023), no. 3.

[4] C. Agudelo-Vero, W. Leduc, A.R. Mels, and H. Rijnaarts, *Harvesting urban resources towards more resilient cities*, Resources Conserv. Recyc. **64** (2012), no. 3, 3–12.

[5] M. Abdul Ahad, S. Paiva, G. Tripathi, and N. Feroz, *Enabling technologies and sustainable smart cities*, Sustain. Cities Soc. **61** (2020), no. 1, 1–11.

[6] S. Caputo, *Urban resilience: A theoretical and empirical investigation*, PhD Thesis, Coventry University, England, 2013.

[7] J. Clement and N. Crutzen, *How local policy priorities set the smart city agenda*, Technol. Forecast. Soc. Change **171** (2021), no. 4, 120985.

[8] S. Davoudi, *Resilience: A bridging concept or a dead end?*, Plann. Theory Practice **13** (2012), no. 3, 299–307.

[9] A. Gren, J. Colding, M. Berghauser-Pont, and L. Marcus, *How smart is smart growth?*, Examin. Envir. Valid. Behind City Compact. **48** (2019), no. 1, 580–589.

[10] K. Hail Moghadam and A. Nouri Kermani, *Investigating the role of urban management in making the city smart (case of study: District 5 of Tehran municipality*, Geograph. Sci. (Appl. Geo.) **15** (2018), no. 30, 127–138.

[11] K. Hosseinzadeh Delir, M. Mohammadian, and R. Sardari, *A review of the concept of urban resilience*, Quart. J. Urban Design Stud.d Urban Res.**2** (2018), no. 3, 69–78.

[12] Ch. Hudson and M. Rönnblom, *Is an 'Other' city possible? Using feminist utopias in creating a more inclusive vision of the future city*, Futures **121** (2020), 102583.

[13] Y. Im Cho, *Designing Smart Cities: Security Issues, Suwon, Korea: Dept, Of Computer Science*, The University Of Suwon, Korea, 2012.

[14] H. Ismailzadeh, *Analysis of the relationship between smartness and sustainability in urban spaces (Case study: District 6 of Tehran)*, Geo. Plann. J. **23** (2018), no. 68, 1–21.

[15] E. Ketabchi and M. Tseshpour, *Urban resilience: presenting a conceptual model of urban planning and management*, Architect. Stud. **1** (2017), no. 1, 1–10.

[16] E. Ketabchi and M. Resaeipour, *Futures studies of Post-Covid -19 urban management paradigm with emphasis on urban resilience (Case: Tehran Metropolis)*, J. Geograph. Stud. Mount. Areas **13** (2023), no. 1, 90–112.

[17] B. Mattoni, L. Pompei, J. Losilla, and F. Bisegna, *Planning smart cities: comparison of two quantitative multi-criteria methods applied to real case studies*, Sustain. Cities Soc. **60** (2020), no. 12, 102249.

[18] F. Naamjooyan, M.T. Razovian, and R. Sarwar, *Urban resilience is a binding framework for the future management of cities*, Sarmeen Geo. Quart. **11** (2016), no. 1, 36–58.

[19] D. Prasad and T. Alizadeh, *What makes Indian cities smart? A policy analysis of smart cities mission*, Telemat. Inf. **55** (2020), no. 8, 101466.

[20] F. Trindade Neves, M. Castro Neto, and M. Aparicio, *The impacts of open data initiatives on smart cities: A framework for evaluation and monitoring*, Cities **106** (2020), no. 20, 102860.

[21] A. Tzioutziou and Y. Xenidis, *A study on the integration of resilience and smart city concepts in urban systems*, Infrastructures **6** (2021), no. 2, 24.