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Investigating the Relationship between Resilience and the Situation of Risk in the Face of Natural Disasters

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Abstract

Creating cities resilient in multiple dimensions could be appropriate and economic thanks to strengthening town structure to alter crises and natural and unnatural hazards. Therefore, the aim of this study is to investigate the connection between the resilience in the city of Sari and the risk situation towards natural disasters. Data analysis with geographic information system (GIS), Decision making trial and evaluation laboratory (DEMATEL), and analytic network process (ANP) is carried out. The variables studied to explain the resilience of the city of Sari are the conditions of open spaces, incompatible land uses, land bed, building resistance, access, property, density, which are evaluated in the presented paradigm. After collecting the scores and multiplying the scores by the coefficients obtained from the statistical procedures of an urban resilience model, the final computation of urban resilience in Sari was performed. The results show that its value has been calculated as 5.44398, which shows that there is an urgent need to develop programs and reform structures to increase the level of resilience in this urban area. One of the effective factors in urban resilience is the high level of social participation in crisis, which is necessary in this area. It is suggested to create educational programs in the community, so that they can maximize the level of communication and participation of employees.

1. Introduction

Geographic phenomena that occur routinely on a tiny scale around the globe are known as Natural hazards. A natural hazard could convert to a disaster. They may cause serious disruptions in the operation of a society, involving exhaustive human, material, financial or environmental damages (Hishan et al., 2021; McBean & Ajibade, 2009; Panda et al., 2020). The intensity and frequency of disasters and their related effects (Serdar et al., 2022) are increasing.

From 2005 to 2014, natural disasters affected more than 1.7 billion population worldwide and triggered $1.4 trillion in damage (Serdar et al., 2022). Natural disasters are sudden (VanLandingham et al., 2022), uncontrollable (Vu et al., 2023) and unexpected events (Basumatari et al., 2023); These include floods and storms, which are assumed to be short-term natural events with devastating effects on human life and the overall economy (Amin et al., 2021). The experience gained in events such as floods and earthquakes have revealed that both the level of preparedness and the response of the affected towns were not high enough, while the recovery process was long and costly. For this reason, it is essential to improve disaster risk reduction measures and intelligent and strategic urban planning in risk areas (Rus et al., 2018).

The impact of natural disasters on communities living in risk areas is broad and intricate (Hambati & Yengoh, 2018). Cities must react quicker and extra efficaciously to expect and decrease the outcomes and related risks. Promoting urban resilience in relation to environmental, socio-economic and political domains has increasingly attracted the eye of scholars and nearby authorities (Ribeiro & Gonçalves, 2019). Previous studies have shown that cities with high resilience can respond to disasters quickly and effectively, reducing the human, economic, and environmental losses caused by disaster risks. Therefore, improving urban resilience and reducing disaster shock could be a key issue in the urbanization process (Lu et al., 2022).

Cities should have their own indicators. Different contexts with different disaster risk are shaped by a city's demographic characteristics, data collection capacity and organizational structure, among other things. For example, earthquake-prone cities need to develop a robust and specific risk assessment and response capacity, while cities not normally prone to earthquakes do not include this risk in their plans and programs. Resilience indicators can be created in different ways. The indicators framework can contain quantitative or qualitative data or a mixture of both. There may be a mix of observational data on actual outcomes and data from modeling techniques to predict future trends and events (Winderl, 2014). They may be supported municipal censuses or different pre-existing data sets, but they will even be supported interviews, expert evaluations, modelling strategies, and public session (Figueiredo et al., 2018).

Traditionally, maximum significance evaluation techniques used to signify importance amongst standards via weighting alternatives are based on assumptions of additivity and independence. In reality, human beings have discovered that the usage of such an additive version isn't always constantly feasible due to the dependency and remarks between the marginally one-of-a-kind standards. To resolve the problem, Saati proposes the analytic network process (ANP) method. The overall manner to remedy the above trouble is straightforward and beneficial. but, for ANP techniques, it does now not appear reasonable to apply the averaging approach (equal cluster weight) to attain the weighted super matrix, due to the fact there are one-of-a-kind degrees of influence among the standards.

Yang and Tzeng (2011) proposed a brand new concept of extracting a cluster-weighted hypermatrix to obtain criteria weights, within which obtaining the full influence matrix and considering as the basis of the normalization hypermatrix is useful to calculate ANP weights with the Decision making trial and evaluation laboratory (DEMATEL) method and possible to unravel the irrational situation. Yang et al. (2008) developed a Multi-criteria decision-making (MCDM) model called DANP that integrates both approaches. DEMATEL is used to get the full influence matrix for the clusters and ANP is used to get the super matrix in terms of the nodes weighted by the DEMATEL results. Then this matrix is finalized to get the priorities of clusters and nodes (Quezada, López-Ospina, Palominos, & Oddershede, 2018). Every city has unique characteristics, suitable criteria and therefore suitable assessment approaches.

All of the variables and challenges present limit the ability to develop a simple holistic assessment method that can be scaled to consider multiple networks simultaneously with reasonable accuracy. To meet this challenge, the proposed solution of this research is based on the concepts of multi-criteria decision analysis and using effective factors in studying urban resilience. For this purpose, cause-effect mapping, determination of the internal relationships of the criteria and mapping of the location of vulnerable areas in the city of Sari will be carried out.

2. Data and Methods

2.1. Study Area

Sari city is the capital of Mazandaran province (Figure 1). In terms of geographical location, this city is located at 53 degrees and 3 minutes' east longitude and 36 degrees and 34 minutes' north latitude and its average altitude is about 40 meters above sea level. Sari, as the capital of Mazandaran province, has 6 districts, 4 cities and 15 villages. According to the results of the general population and housing census in 2016, this city has a population of 504,298, of which 253,451 are men and 250,847 are women. The city of Sari has a special position due to its proximity to Tehran and being on the communication route of Khorasan Razavi. The closest cities around Sari are Qa'em Shahr in the west, Neka in the east, Jouibar in the north and Kiasar in the south.

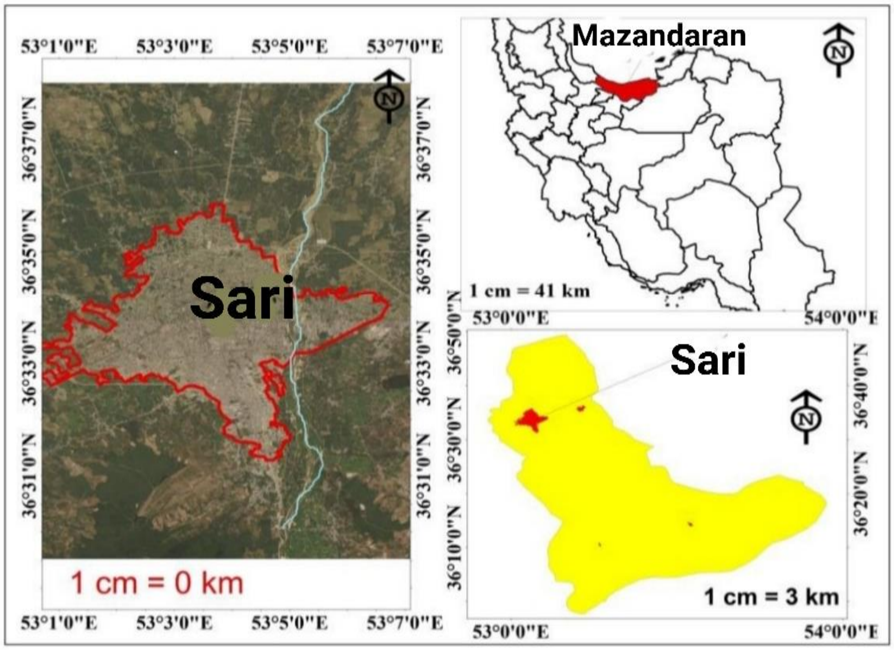

Figure 1. Location of the Study Area (cartography: writers)

In terms of natural location, Sari is located in the south of the Caspian Sea. The southern and southwestern parts of it is led to mountains and low satellite hills. Tajan River, which is one of the wateriest rivers in the province, originates from the southern heights of the city with its tributaries and after passing through the eastern part of the city, moves to the north and the Caspian Sea. In terms of general topography, the city of Sari is located at an altitude of 0-100 and the general slope of the city from south to north is very gentle. The northernmost point of the city is about 12 meters high and the southernmost point (the beginning of Baladza) is about 80 meters high. The city of Sari with the largest earthquake fault in the country with a length of 600 km is only 5.3 km away. Tajan River originates from Chahardangeh, Dodangeh and Hezar Jerib mountains and enters the Caspian Sea after passing through Sari city. The average maximum temperature in the coldest month of the year (January) was 1 ° C and the average minimum in the warmest month of the year (July) was 33.6 ° C.

By comparing these figures and in general by comparing the figures related to the average maximum and average minimum air temperature in different months of the year, it is observed that in Sari, the average air temperature does not fall below zero (Mazandaran Meteorological annals). In general, in the functional zoning system, four zones have been identified in the city of Sari: (1) Residential area, (2) Activity area, (3) Mixed area, (4) Protective zone, and (5) Green zone. The spatial arrangement of land uses and the distribution system of zones at the area level indicate the dominance of residential land use over other land uses. Another area that has been identified at the area level is the activity area. The area of activity is very important due to the commercial-service center of the city in relation to the surrounding areas and the relatively large area of its service area and operates on a metropolitan scale. The mixed zone, in which the mixing of residential use with other service uses is observed, is mostly located in the areas around the main thoroughfares in the area (General plan of Sari city).

2.2. Urban resilience indicators

Raiesian, Ilanloo, Ebrahimi, and Bozorgmehr (2020) introduced the urban resilience indicators including Land bed and urban infrastructure, Building resistance, Physical environment, Uses, Economic, Social, Open spaces and Natural dimension. Table 1 indicates sub-indicators of this study.

Table 1. Sub-indicators of this study

Sub-indicators	Number
The rate of continuous protection and restoration process	1
Number of green spots and public open spaces	2
Regular structural geometry	3
The amount of capacity to absorb open spaces	4
Open spaces use flexibility	5
Compatibility of uses with each other	6
The level of safety of urban facilities	7
The degree of infrastructure fit with the height and materials used	8
Standardization of building height density	9
Distance to hazardous facilities	10
Sustainability of vital urban infrastructure	11
The number of safe spaces	12
The height of the building floors	13
The rate of physical resistance of the land	14
The strength of existing buildings	15
The degree of compatibility of land uses after accidents	16
The distance from the faults	17
The distance from the waterway	18
Shelters capacity	19
The degree of environmental sustainability of the land for landfilling	20
The degree of economic stability and stability in the region	21
Spatial safety capacity	22
The degree of diversity of axes and major urban functional centers	23
The density of pipelines and energy on the land	24
The rate of growth dynamics and economic diversity	25
The extent of access to government financial services	26
The standardization of land area	27
The rate of employment	28
The amount of spatial circulations	29
The extent of social justice	30
The rate of population density	31
The level of social participation	32
The degree of resilience of the land bed to developmental changes	33
The resilience of the land bed to increase population density	34
Land slope	35

Source: Analysis, 2023

2.3. Spatial Modelling

This phase includes standardization, expert work, weighting, summary analysis, and aggregation and validation of all factors considered in the decision-making process. Because all data is collected in different ways in different formats, the first step of multiple-criteria decision analysis (MCDA) is to normalize this data so that it can be used for comparisons. In this research, DEMATEL-ANP method is used by experts to analyze the factors. The following scale is used in the assessment: (1) Very low impact; (2) Low impact; (3) Moderate impact; (4) High impact; (5) Very high impact.

2.4. Modelling with DEMATEL and ANP

DANP is a decision support tool that can establish connections and dependencies between different topics to facilitate problem solving (Chiu et al., 2013; Hsieh et al., 2017). This model can verify the interdependence of variables and traits and establish a relationship that reflects the traits with an underlying system and evolutionary process (Chiu et al., 2013). DANP is a hybrid multi-criteria decision making that is a combination of DEMATEL and ANP (Liu et al., 2014). DEMATEL solves the problem of agent generation in a multi-agent system (Uygun et al., 2015). Using graph theory and matrix tools, the DEMATEL method can calculate the cause and effect of each factor and transform the relationships between the factors into a structural model to visually represent the interdependence between them. The DANP model uses a composite matrix of factors to determine the weight of each factor, instead of the usual pairwise comparison matrices in ANP (Wang et al., 2018). The main steps of the DANP method are as follows:

2.4.1.DEMATEL Technique

The DEMATEL method turned into developed by way of the Battelle Memorial association studies center in Geneva. This approach is primarily based at the concept of pairwise contrast of choice making traits. The usage of this technique, it is possible to directly examine the interactive courting between the variables of a complicated device to determine the direct and oblique relationship and the impact levels between extraordinary variables. The different phases in the DEMATEL approach are as follows (Wu & Chang, 2015):

1. Step 1: Build a direct relation matrix
   In this step, the variables are as compared in pairs in a matrix with an influence range between 0 and 4. This range is defined as follows:

   0 = no impact, 1 = low impact, 2 = moderate impact, 3 = high impact, and 4 = very high impact.

2. Step 2: The normalization of the direct matrix

   In this stage, the normalization of the stage 1 matrix is done by multiplying the coefficient k in the stage 1 matrix according to the eq.1 below.

   $$Step\ 2 = k \times Step\ 1 \ldots \ldots \ldots (eq.1)$$

   k is a number obtained from the relationship according to the eq.2 below.

   $$(k = \frac{1}{max \sum_{j=1}^{n} a_{ij}} \text{ ‹}1 \leq i \leq n \text{ and } i, j = 1,2, \ldots, n). \ldots \ldots \ldots (eq.2)$$

3. Step 3: Estimation of total relation matrix

   The total relation matrix is obtained from the following relation (eq.3):

   $$Step\ 3 = Step\ 2(I - Step\ 2)^{-1} \ldots \ldots \ldots (eq.3)$$

4. Step 4: Determination of the influenced degree (R) and influencing degree (J)
5. Step 5: Definition of R+J as Prominence and R-J as relation.

2.4.2.Analytic Network Process (ANP)

The phases in the ANP approach are as follows:

1. Step 1: during this step, the conceptual model is meant and therefore the relationships among clusters and nodes are examined.
2. Step 2: Super Decisions software is employed to check criteria across the whole network to form an unweighted super matrix supported pairwise comparisons. During this step, two elements are compared by decision makers. Pairwise comparisons are made supported scores from 1 to 9 (Zelenović et al., 2012). A reciprocal value is applied to every number to point inverse comparison. The values of the pairwise comparisons are laid out in the comparison matrix and therefore the local priority vector from the eigenvector. Like AHP, pairwise matrix consistency should be less than 0.1 (Şener et al., 2011).
3. Step 3: The weights made up of the previous steps are introduced to the super matrix consisting of all network components, which shows the relationships between them. At this stage, the super matrix is named the first hyper matrix.

4. Step 4: Cluster weights should be calculated to weight the initial super matrix. After obtaining the cluster weight matrix, the initial hyper matrix will be measured by multiplying the cluster weights matrix by an initial hyper matrix (Nekhay et al., 2009). The new matrix obtained is understood as weight hyper matrix.
5. Step 5: Finally, the weight super matrix is multiplied by itself n times to achieve the limit super matrix. Some hyper matrices may have a cyclic effect that results in two or more ultimate limit hyper matrices. Having equal columns and showing international priority vectors taken into consideration because the main features of the limit hyper matrix (Nekhay et al., 2009).

The details research flow is illustrated in Figure 2.

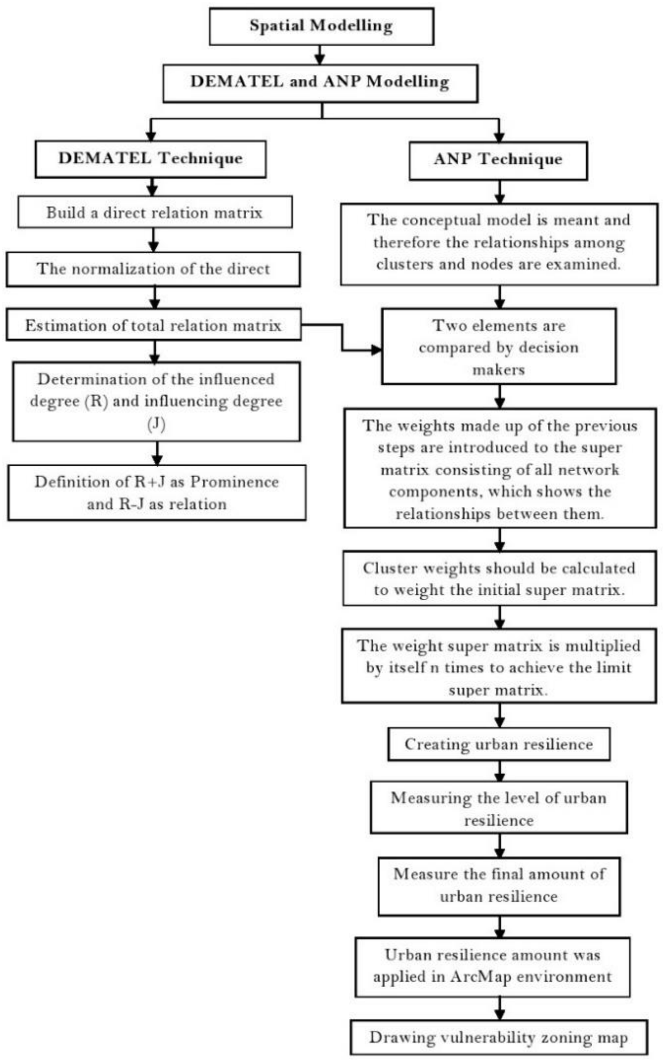

Figure 2. Research Steps

3. Results and Discussion

After accumulating the DEMATEL questionnaire from specialists (urban planners) and calculating the average of all their scores, the impact and effectiveness of the indicators of the "urban resilience" model have been calculated. In this regard, it ought to be mentioned that because of the fact that in this observe there are eight indicators, the scores are satisfied to one decimal place, but in the calculations done with Excel software, the scores are calculated correctly and accurately (Table 2).

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Table 2. Existing Intensity of Direct and Indirect Relationships of Indicators to Each Other "Intra-Organizational integration"

R-J	R+J	J	R	Abbreviation	Available intensity
0.325	0.870	0.272	0.598	D1	Land bed and urban infrastructure
0.069	0.757	0.343	0.413	D2	Building resistance
0.070	0.668	0.298	0.369	D3	Physical environment
-0.086	0.762	0.424	0.337	D4	Uses
-0.368	0.884	0.626	0.258	D5	Economical
-0.034	0.627	0.331	0.296	D6	Social
0.024	0.364	0.169	0.194	D7	Open spaces
-0.122	0.590	0.356	0.234	D8	Natural dimension

In the Table 2, the order of the factors from column (R) represents the hierarchy of penetrating factors and the order of the elements from column (J) represents the hierarchy of the elements under influence. The actual location of each element in the final hierarchy is determined by the columns (R-J) and (R+J), So that (R-J) indicates the placement of a factor along the axis of widths, and this placement if (R-J) is positive, it is definitely a cause and if (R-J) is negative, it's going to truly be affected. (R+J) represents the full depth of a factor along the duration axis both in phrases of penetrating and being affected. Table 3 represents relative intensity of direct and indirect relationships between sub-indicators

Table 3. Relative Intensity of Direct and Indirect Relationships between Sub-Indicators

(R-J)	(R +J)	J	R	Existing relative intensity of direct and indirect relationships of the "urban resilience" model
-0.18	0.258	0.219	0.038	27
-0.15	0.248	0.202	0.046	33
0.018	0.223	0.102	0.120	2
0.040	0.258	0.109	0.149	9
0.020	0.170	0.074	0.095	8
0.048	0.204	0.078	0.126	20
-0.020	0.239	0.130	0.109	16
-0.118	0.219	0.196	0.050	34
-0.010	0.242	0.126	0.115	30
0.006	0.234	0.114	0.120	21
0.005	0.248	0.127	0.121	32
0.023	0.286	0.131	0.154	3
0.001	0.241	0.120	0.121	25
0.009	0.243	0.116	0.126	4
0.018	0.208	0.095	0.113	13
-0.020	0.202	0.111	0.090	28
-0.022	0.223	0.123	0.100	5
-0.011	0.192	0.101	0.090	31
-0.025	0.244	0.134	0.109	1
0.025	0.266	0.120	0.146	15
-0.004	0.252	0.128	0.123	23
0.027	0.260	0.116	0.144	29
0.076	0.260	0.096	0.164	11
0.077	0.247	0.087	0.162	10
0.042	0.200	0.079	0.121	24
-0.032	0.259	0.146	0.113	22
-0.043	0.247	0.125	0.121	6
0.002	0.197	0.097	0.099	26
-0.033	0.207	0.120	0.086	19
0.033	0.269	0.118	0.151	12
0.079	0.251	0.086	0.165	7
0.055	0.202	0.073	0.128	14
0.015	0.077	0.046	0.031	35
-0.054	0.258	0.156	0.102	17
-0.053	0.255	0.154	0.101	18

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The weights of the main indicators of the "urban resilience" model was calculated. In order to test the appropriateness of the scores given by experts, the incompatibility rate is used, which is calculated by Super Decisions software. The incompatibility rate of the paired comparison questionnaire of the main indicator has been calculated as 0.0417, which is an acceptable number. Table 4 shows the main weights of the "urban resilience" model, which is calculated from the ANP technique and using Super Decisions software.

Table 4. The Weights of the Main Indicators using the Network Analysis Process Approach in the Urban Resilience Model

Rank	Weight	The main indicator of urban resilience model
1	0.258	Building resistance
2	0.206	Land bed and urban infrastructure
3	0.167	Open spaces
4	0.154	Natural dimension
5	0.078	Economical
6	0.132	Physical environment
7	0.103	Uses
8	0.056	Social
	0.0439	Incompatibility rate

Table 4 shows the weights of the main indicators using the network analysis process approach in the urban resilience model. Thus, the building resistance indicator with a weight of 0.258 has the first rank. And the social indicator with a weight of 0.056 is in the last rank. The compatibility rate is 0.0439, which is an acceptable number. Table 5 shows adjustment of the weights of the main indicators with the weight coefficients of the main indicators based on their relationships.

Table 5. Adjustment of the Weights of the Main Indicators with the Weight Coefficients of the Main Indicators based on their Relationships

Ranking	Adjusted weights	Coefficients of the main indicators based on correlation	The weights of the main indicators	The main indicator
1	0.276	0.168	0.258	Building resistance
2	0.235	0.179	0.206	Land bed and urban infrastructure
3	0.184	0.174	0.167	Open spaces
4	0.122	0.149	0.132	Physical environment
5	0.118	0.143	0.129	Natural dimension
6	0.091	0.139	0.103	Uses
7	0.054	0.109	0.078	Economical
8	0.031	0.088	0.056	Social

According to the obtained results, the compatibility rate of physical environment sub-indices has been calculated as 0.04174, which is an acceptable number. The first rank belongs to the variable of 9 with a weight of 0.344. And the fifth rank belongs to 29 with a weight of 0.085. The compatibility rate below the use indicator indices has been calculated as 0.05311, which is an acceptable number. The compatibility variable of uses with each other with a weight of 0.524 is in the first place.

The incompatibility rate of the entries comparison questionnaire of the building resistance indicator sub-indices is calculated as 0.4158, which is an acceptable number. The amount of continuous protection and restoration process with a weight of 0.360 in the first place and the amount of strength of existing buildings with a rate of 0.102 are in the fifth place. The incompatibility rate of the pairwise comparison questionnaire was calculated below the indices of the open space indicator of 0.00972, which is an acceptable number. The variable of the number of green spots and public open spaces with a weight of 0.426 is in the first place. The incompatibility rate of the pairwise comparison questionnaire was calculated below the social indicator indices of 0.00138, which is an acceptable number. The rate of social justice with a weight of 0.336 is in the first place. The incompatibility rate of the pairwise comparison questionnaire of the economic indicator sub-indices is

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calculated as 0.03127, which is an acceptable number. The variable of economic stability and stability in the region of 0.310 is in the first place.

After determining the weights of the sub-indicators of each indicator, the weights of the sub-indicators were equalized. Table 6 shows the unification of sub-indicator weights in the network analysis process method.

Table 6. Unification of Sub-Indicator Weights in the Network Analysis Process Method

Uniform weights	Number
0.099745	1
0.078941	2
0.072695	3
0.053993	4
0.052058	5
0.048055	6
0.046864	7
0.04464	8
0.043196	9
0.039799	10
0.034147	11
0.031895	12
0.030958	13
0.028731	14
0.028731	15
0.028246	16
0.023550	17
0.023431	18
0.023105	19
0.018604	20
0.016818	21
0.016575	22
0.015407	23
0.014836	24
0.013776	25
0.012482	26
0.01201	27
0.0112	28
0.010674	29
0.010652	30
0.010545	31
0.010431	32
0.00942	33
0.007771	34
0.23105	35

After creating urban resilience, a framework for measuring the level of urban resilience in Sari has been used to measure it. In the meantime, geography experts related to each of the septet areas have collected points in each from the indicators, the indicators are rated from 1 to 10, so that 1 has the lowest score and 10 have the highest score. After collecting the scores and multiplying the scores by the obtained coefficients, the statistical processes of an urban resilience model measure the final amount of urban resilience in Sari, the value of which is calculated as 5.44398, which indicates there is an urgent need to develop programs and reform structures to increase the level of resilience in this urban area. Figure 3 shows the final score of the octet indicators in the city of Sari, with:

1. Range 0 to 2.5 is a critical and dangerous situation (red)
2. Range 2.5 to 5 Warning status (yellow)
3. Range 5 to 7.5 Status needs correction (blue)
4. Range 7.5 to 10 suitable and acceptable conditions (green)

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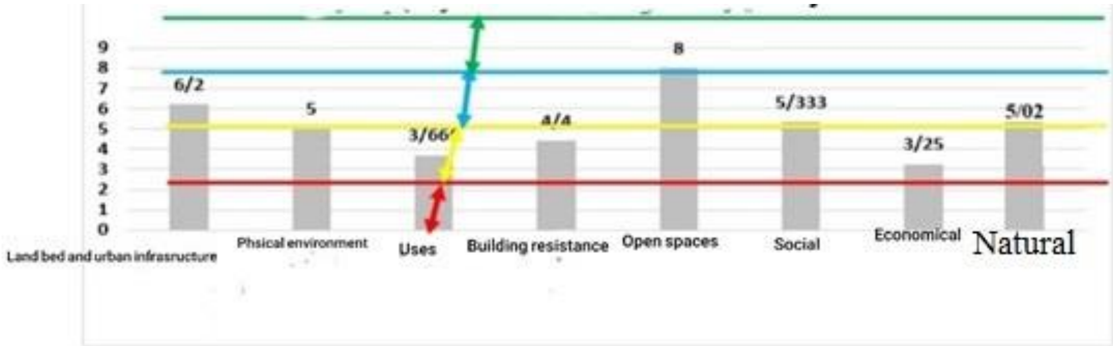

Figure 3. The Final Score of the Octet Indicators in the City of Sari

Table 7 shows urban resilience scores in each of the septet axes in Sari.

Table 7. Urban Resilience Scores in Each of the Septet Axes in Sari

Situation	The average of situation	General points by taking into account the coefficients	Eight indicators
Need to modify and improve	6.2	1.46126	Land bed and urban infrastructure
Warning status	5	0.65912	Physical environment
Warning status	3.666	0.35143	Uses
Warning status	4.4	1.1235	Building resistance
Appropriate and acceptable situation	8	1.50488	Open spaces
Warning status	5.333	0.16869	Social
Warning status	3.25	0.17507	Economical
Warning status	5.02	1.12012	Natural dimension

In the last step, the weight of each layer was applied in ArcMap environment and the vulnerability zoning map of Sari city in the face of environmental hazards was prepared (Figure 4).

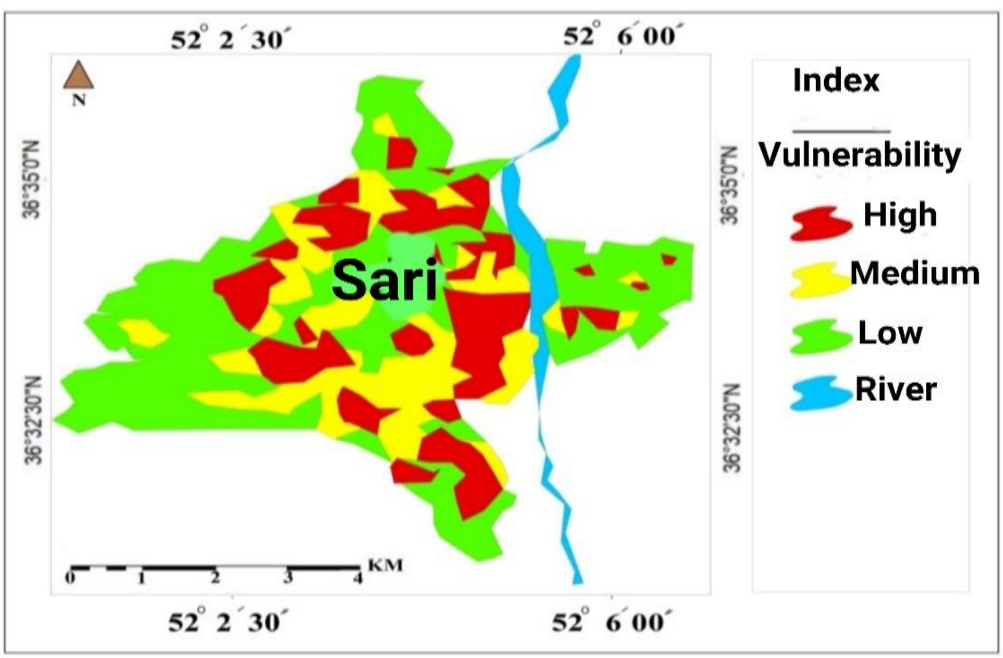

Figure 4. Zoning Map of Vulnerability of Sari City in the Face of Natural Hazards

Urban resilience is one of the important criteria in the process of urban development and population density in different regions, because the higher the level of urban resilience, the more assurance of living in an urban environment is guaranteed, therefore, policymakers and decision makers in the field of urban management are constantly measuring and monitoring resilience in urban areas, in order to examine the existing disadvantages and strengths and weaknesses, and if necessary, to adopt appropriate solutions to correct and improve the obstacles and problems to increase the level of urban resilience in order to increase capacity at the time of the accident in the urban area.

Therefore, it is necessary to identify the factors affecting urban resilience and also, according to the nature and requirements of each urban area, to create a suitable model for measuring urban resilience, and finally according to the obtained model, measure the level of urban resilience and determine its status, weaknesses and problems, so that the level of urban resilience can be increased in the natural disasters and accidents, these results are consistent with the research of Mavhura et al. (2021) and Javadpooret al. (2021). Eraydin (2013) said in this regard, the characteristics that can increase the resilience of cities against various vulnerabilities include recovery, connectivity, capital creation, adaptability, robustness, flexibility and changeability. Zhao et al. (2022) also stated that resilience can be increased by promoting institutional organization in order to strengthen the development of healthy urbanization and planning and building safe cities.

According to the obtained results, urban resilience scores of land bed and urban infrastructure indicator are equal to 6.2 and economic equals are equal to 3.25, which have the highest and lowest scores, respectively. The final score of the social indicator is 5.33, which is the second highest score indicator. The score of the social indicator is higher than the economic indicator, the results of which are consistent with the studies of Bastaminia et al. (2017). The results also showed that the central areas of the city are vulnerable due to higher population, higher density of buildings and lower slope of these areas, which is consistent with the results of research by Asadzadeh et al. (2015).

4. Conclusion

According to the results obtained from the study of urban resilience in urban planning, it can be concluded that it has a favorable and acceptable situation only in the open spaces indicator, but unfortunately in other septet indicators, corrective and development strategies and measures are needed. But unfortunately, in the other septet indicators, strategies and measures for improvement and development are needed, among which the economic indicator, land uses, and the resistance of buildings are in a state of alert, the amount of which is calculated below the five points, which in this regard, in order to improve and develop the level of urban resilience, it is necessary to take the necessary measures regionally or nationally, in the meantime, part of it can be done by local and provincial authorities establish working groups to develop and improve reform programs.

Also, regarding economic and social indicators, it is necessary that with the support of the government of the country in this area, by fundraising allocated to increase employment and business, as well as development budgets to carry out improvement and reform measures. In fact, regarding the improvement of urban resilience, two views should be applied correctly, a control and monitoring view to prevent the growth and increase of factors that lead to lower urban resilience and the structure of urban development in a non-scientific and standard way. Contrary to the goals of urban resilience to grow and develop, and the second view is the existence of a reform structure and improvement, because in the city of Sari there are many areas and neighborhoods that have many problems due to lack of scientific and systematic view on urban resilience. They are in a state of crisis alert, which is necessary to try to moderate the negative consequences in these vulnerable areas by adopting corrective and remedial measures. The vulnerability zoning map of Sari city, which has been prepared in three zones of high, medium and low, shows that the vulnerability of the region in the southern parts is central.

Neighborhoods should be created based on pathology in terms of the strength of buildings, by creating accurate and intelligent planning to implement retrofitting and remediation processes of neighborhoods that have the highest vulnerability rate, it is also necessary in this regard the height of floors and shape Manage the geometry of buildings in a standard and scientific way, in order to prevent the arrival of relief processes in the event of unexpected events in these areas. Due to the importance and position of the ground and urban infrastructure in the rate of urban resilience in the city of Sari, it is recommended that in this regard, the distance between residential and sensitive areas to hazardous centers and facilities be properly placed and implemented, and if sometimes Proximity and distance should not be observed, by adopting measures and strategies to secure a safe distance, as well as the use of tools and equipment that prevent damage to injuries at the time of the accident, due to the importance of the role of the physical environment indicator.

In the process of urban resilience, it is suggested to increase the safety capacity in different urban areas So that by creating a comprehensive plan and proper management of resources and capacities according to population density and needs of the region, the amount of vulnerability of the region and also the construction texture there, according to the philosophy of the region and according to the amount of accidents created there Create safety capacities such as shelters and centers that can, in times of emergency, properly and in proportion to the capacity, try to attract the affected areas and people in such neighborhoods.

Considering the importance and role of the open spaces indicator in the rate of urban resilience, it is recommended that the capacities of open spaces around neighborhoods and areas be properly examined and identified, and also the flexible use of open spaces be accurately measured and evaluated. In case of accidents, it is possible to manage, coordinate and organize people in these areas in a timely and timely manner to make them safe. Given the importance of social indicators in urban resilience, it is recommended that, by creating appropriate mechanisms to identify and measure the amount of justice that exists in different areas and develop effective programs to increase the level of social justice to reduce anomalies. Social and delinquent crimes, on the one hand, and aligning individuals in times of crisis by equalizing the distribution of justice within the deadline are very important, therefore, given the population density in the neighborhoods, as well as existing capacities and potentials should be tried to resolve class differences and the distribution of social justice as much as possible with proper planning.

Finally, one of the effective factors in urban resilience is the high level of social participation in crisis, which is necessary in this area. It is suggested to create educational programs in the community, so that they can maximize the level of communication and participation of employees.

5. Declarations

Funding and/or Conflicts of interests/Competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. **Data Availability Statement:** The datasets generated during the current study are available from the corresponding author on reasonable request.

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