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Investigating the Resilience of Bandar Abbas Neighborhoods against Disaster

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Abstract

Background: Urban planning and urban planning activities have increased the pressure on nature and weakened its resilience, often bringing negative and even irreparable consequences.
Objectives: One of the most important issues in urban management in recent years is the emergence of resilient cities. Hormozgan is one of the most important provinces of the country, and Bandar Abbas, in the center of this province, is considered one of the major coastal cities of Iran from a national point of view.
Methods: To identify and examine the resilience of Bandar Abbas against environmental crises, based on which an information base was created, the place and spatial information of this database was prepared in 5 criteria and 29 sub-criteria. They include 1. socio-economic criteria, 2. structural criteria, 3. access criteria, 4. physical criteria, and 5. Ecological criteria. In the next step, to weigh and value the research criteria and sub-criteria in the resilience model of Bandar Abbas, the network analysis method (ANP) was used. In this model, the first 50 questionnaires were prepared by the Delphi method and distributed among experts in the field of environment and disaster management.
Results: The findings of this study indicated that the weight and value of ecological, socio-economic, physical, accessibility, and physical-structural criteria in resilience were 0.256, 0.236, 0.194, 0.171, and 0.141, respectively. Among the ecological criteria, the sub-criterion of distance from polluted points, the socio-economic criterion, the sub-criterion of access to medical-health centers, the sub-criterion of access to medical-health centers, among the physical-structural criteria, flood risk sub-criterion, and functional zone sub-criterion, and among access criteria, the sub-criterion of access to the fire station obtained the highest values in resilience.
Conclusion: Environmental crises, such as earthquakes, floods, accidents, air pollution, and storms, have resulted in the environmental vulnerability of the city and posed serious threats to the security of Bandar Abbas. A thorough understanding of the vulnerability of Bandar Abbas against urban environmental crises will enable policymakers to propose management solutions to reduce vulnerability and risk and increase resilience. Consequently, the main goal of this study was to evaluate the resilience of Bandar Abbas against environmental crises. The results of this study can be of great help in the decision-making of city managers and the lives of city residents.

Keywords: Coastal cities, Disasters, Resilience, Urban planning

1. Background

Today, crises in various environmental, social, physical, and economic fields, as well as the unbridled growth of cities, have made urban resilience look more special. Explaining resilience against threats is knowing how the social, economic, institutional, political, and executive capacities of urban communities influence resilience and identify different dimensions of resilience in cities (1). Like other parts of the world, cities in Iran have been faced with much climate damage for many years (2). The shape and headquarters and the morphology of the city is known as an effective tool in rapid resilience against tsunami and flood crises (3).

In Tehran, Districts 1, 3, 6, 9, 11, and 18 have the most resilience, and Districts 12 and 16 have the least resistance and resilience against natural crises (4). In Spain, most cities are not in a favorable situation in terms of resilience, and to achieve resilience, such measures as reducing resource consumption, promoting local business, creating an environment for participation, and diversifying the local economy, should be increased (5). In every region of North Dhaka in Bangladesh, the level of resilience is different at the neighborhood scale, and paying attention to urban infrastructure and its improvement is not the answer to dealing with natural crises, and the continuous approach of change in planning is necessary to deal with crises (6).

Few studies have addressed the characteristics of the city against disasters and whether this city has a sustainable development that can cope with disasters or not (7). The resilience of Shenzhen, China, against landslides caused by heavy rainfall and topography, was investigated using the Support Vector Machine (SVM) model and the Delphi Hierarchy Technique (Delphi AHP). The results demonstrated that the new areas of Dapeng and Guangming with shale soils and complex topography and high rainfall are areas with weak social resilience (8).

Studies related to the resilience of Tonga against floods and sea storms caused by climate change and global warming indicate that this country is highly vulnerable to natural crises caused by global warming (9). In the Tehran metropolis, the resilience against floods caused by overflowing rivers and street surface water is high in districts 6 and 22, while District 1 has the least resilience (10). To increase resilience against climate change and global warming along with the high rate of urbanization in India, societies need planning and financial strengthening, especially improving infrastructure services, so that they can be ready to deal with natural crises (11). In Taiwan, the most urban damage caused by natural crises occurs in the initial moments of the disaster, and the infrastructures are quickly damaged (12).

To answer and deal with urban environmental crises, the researchers, using quantitative methods and questionnaires, first identified the vulnerability of different urban areas against these crises and investigated the capacity of cities using the weighting and multi-criteria decision-making (MCDM) methods (13). In Qazvin, in the measure of the spatial body, the ratio of hospital beds to the population; in the social measure, social capital; In the economic criterion, the area of large-scale business centers; and in the criterion of institutional resilience, the performance index was in an unfavorable state of resilience (14).

The assessment and formulation of a strategy of resilience against urban environmental crises in the old urban context of Faizabad neighborhood of Kermanshah demonstrated that the position of this neighborhood is in a defensive state, and the most important strategy in this context is the formulation of a strategic document and the participation of effective social forces to organize the old urban texture (15). In terms of social resilience, district 3 of Isfahan has the highest resilience due to the optimal number of different service centers, followed by Districts 5 and 1 (16). Districts 3 and 6 have poor resilience due to unemployment, crimes, and inappropriate social behaviors. The study on the resilience of Sanandaj neighborhoods with the ANP model illustrated that Hajiabad, Shalman, and Sartpoule neighborhoods had a suitable resilience (17).

The assessment of the resilience of Babol City with the Vicor ranking model showed that about 50% of the investigated areas in Babol had no resilience and low resilience, and only 25% of the areas were completely resilient in terms of indicators (18). Regarding social resilience against natural crises, regions 1, 2, 3, and 4 of Kerman have the most resilience (19). Among the 20 cities of East Azarbaijan province, Marand, Jolfa, Shabestar, and Tabriz have high resilience against natural hazards, while Malkan, Bonab, Ajab-Shir, Azarshahr, and Ahar have low resilience (20). In the four cities of Tabriz, 39.4 hectares are in poor resilience, and on the other hand, 1167 hectares are in good condition (21).

Among the factors affecting social resilience against natural hazards, especially earthquakes, social capital with the highest weight (0.216) ranks first, followed by human capital (0.184), demographic characteristics (0.168), individual characteristics (0.123), quality of life (0.126), social security (0.112), and psychological readiness of the community (0.05) (22). Khalidi et al. (2018) investigated the resilience of urban areas of Urmia against floods and concluded that District 3 of Urmia is the most favorable region against urban floods and District 4 is the weakest.

2. Objectives

In fact, the main goal of the research is to achieve a comprehensive plan to help designers and urban management specialists provide solutions for the optimal management of natural resources and the optimal use of land in Bandar Abbas. Two main factors help designers and urban planners to achieve their goals as best as possible.

3. Methods

Bandar Abbas, the political-administrative center of Hormozgan province, is located in the southern tip of Iran at 26 degrees 58 minutes north latitude and 55 degrees 88 minutes east longitude from the Greenwich meridian. According to the master plan, the area of the city is around 5323.5 hectares. This city is the center of the central part of Bandar Abbas and is bordered by the Fin part from the north, Qala-Qazi and Takht parts from the east, Bandar Khmeir from the west, and the waters of the Persian Gulf cover the south. The average height of the city is about 0.6 to 40 meters above sea level. (Figure 1. Land use map of Bandar Abbas city). The population of Bandar Abbas City in 2015 was equal to 680,366 people. The city has 4 divisions, 5 cities, and 11 villages.

Regarding the structure and main characteristics of the natural landscapes of Bandar Abbas, two main points should be noted. Firstly, the sea is the natural and limiting edge of the city from the south side, and secondly, the Pooladi heights in the north naturally form the southern and northern views of Bandar Abbas. The most basic feature and natural attraction of Bandar Abbas, which attracts a huge number of tourists every year, is the port feature of Bandar Abbas and its location on the northern coast of the Persian Gulf. Especially, the bright atmosphere of

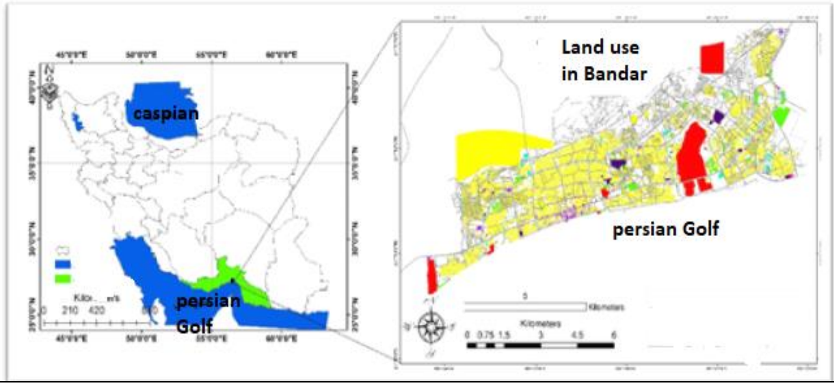

Figure 1. Land use map of Bandar Abbas

Qeshm and Hormuz islands, due to their proximity to Bandar Abbas city, creates a unique and beautiful view. Moreover, the light of the ships that approach the coast to moor in the existing harbors adds to the attraction of Bandar Abbas in terms of views and scenery.

3.1. Bandar Abbas neighborhoods

The neighborhoods of Bandar Abbas can be divided into several general areas.

The central area of the city: it is the primary and old neighborhood of the city with such neighborhoods as Mianshahr, Bazar, Qala-Shahi, Poshtshahr, and Ewazi. The north of the Islamic Republic Boulevard (north of the ring road): This area was formed without a specific plan and in a completely irregular context according to the general conditions of the society.

East of the city: This area is one of the new neighborhoods of the city, which can be referred to as Gul Shahr. Among the neighborhoods that are in unfavorable conditions in terms of social and economic conditions, we can mention Dohzar, Nakhel Nakhda, Behesht Zahra, Posht Shahr, Nayband, Toheed, Isini, Khaje Ata, Sheshund Dazat, and Soro neighborhoods. Among the main centers of Bandar Abbas in terms of traffic and population, we can include Falke Barq, Shahada Square (Memorial), Jahanbar Three Roads, Imam Khomeini Square, Englebal Square, Nakhel Nakhda Intersection, Shahid Haqqani Wharf (Municipality and Municipal Market), Shahr Bazaar (Uzi and Lorry Bazaar), Olive Bazaar, Fish Market, Seyed Mozaffar Imamzade, and Mosalla Shahr.

To identify and investigate the resilience of Bandar Abbas against environmental crises, based on which the database was created, the spatial information of this database was prepared in 5 criteria and 29 sub-criteria (Figure 2). The criteria of this research include 1) socio-economic criteria, 2) physical-structural criteria, 3) accessibility criteria, 4) physical criteria, and 5) ecological criteria. After

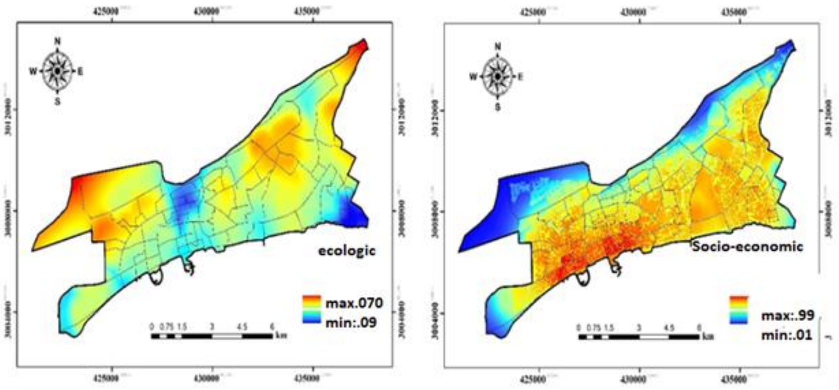

Figure 2. Weight of socio-economic and ecological criteria in resilience

creating a situational-spatial information base and compiling 5 criteria and 29 sub-criteria, to measure and manage the integrity of the resilience of Bandar Abbas against environmental crises with a development perspective approach, one layer for each of the sub-criteria Information was prepared in ArcGIS software, and a distance map was drawn for them with Euclidean distance. Thereafter, fuzzy operators were used for fuzzifying (value between zero and one) each map (sub-criterion), and a fuzzy map was prepared for each

Euclidean distance map. In the next step, to weigh and value the research criteria and sub-criteria in the resilience model of Bandar Abbas, the network analysis method (ANP) was used.

In this model, the first 50 questionnaires were prepared by the Delphi method and distributed among experts in the field of environment and disaster management. After collecting the questionnaire, to calculate the weight and value of each criterion and sub-criterion, the network analysis method was used in the Super decision software, and the output of the model was the fuzzified weight of each criterion and sub-criterion. Following that, the map obtained for each criterion and sub-criterion from the combination of Euclidean distance and fuzzy operators was multiplied by its fuzzy weight obtained from the ANP model in ArcGIS software, and the final map was prepared for each criterion and sub-criterion, demonstrating the value of each criterion in resilience against environmental crises. Subsequently, to superimpose fuzzy weighted maps, fuzzy superimposition operators were used, and for each fuzzy operator, a map was obtained by superimposing 29 sub-criteria (5 criteria).

The level of resilience against environmental crises was assessed. The least square regression (OLS) method was used to identify the best fuzzy operator in combining research sub-criteria and evaluating the resilience model of Bandar Abbas against environmental crises with the development perspective approach from the analysis of spatial relationships between independent variables (5 main criteria) and dependent variable (superimposed maps with fuzzy operators). The TOPSIS technique was used to rank the resilience of neighborhoods in Bandar Abbas against environmental crises. Finally, the classic K-means clustering method was used to classify localities regarding resilience against environmental crises.

4. Results

The results of the weighting of research criteria and sub-criteria from the network analysis model and their effect on the resilience of Bandar Abbas against environmental crises pointed out that the ecological criterion with a weight of 0.256 had the greatest impact on resilience, followed by socio-economic, physical, accessibility, and physical-structural criteria. Moreover, the evaluation results of the sub-criteria illustrated that among the ecological sub-criteria, the distance from water and soil polluting points, with a weight of 0.444, had the most weight and influence in resilience.

Among the economic-social sub-criteria, the sub-criteria of distance from medical-health centers and population density had the highest weight. Among the physical sub-criteria, the distance from the flood path and the land slope had the highest weight, respectively (Table 1 Resilience weights and sub-criteria resulting from fuzzy network analysis)

Table 1. Resilience weights and sub-criteria resulting from fuzzy network analysis

Criterion	Standard Criterion	under the criteria	Substandard weight	fuzzy operator
Ecological	256/0	Distance from marine hazards	0.189	Large
		Distance from polluting points	0.444	Large
		Distance from air and sound pollution	0.258	Large
		green space	0.107	Small
Economic-social	236/0	Distance from commercial centers	0.058	Linear
		Distance from the port	0.141	Linear
		Distance from administrative centers	0.091	Linear
		neighborhood population	0.174	Gaussian
		Distance from educational centers	0.076	Small
		Distance from medical centers	0.255	Small
		population density	0.201	Gaussian
Physical	194.0	Surface topography	0.189	Large
		Geological formations	0.052	Large
		land slope	0.249	Large
		Distance from the epicenter of the earthquake	0.078	Large
		Distance from flood	0.258	Large
		Distance from active faults	0.112	Large
Physical-structural	141.0	Distance from road arteries	0.275	Gaussian
		Functional zone of the city	0.327	Gaussian
		Urban land use	0.193	Gaussian
		Changing neighborhood communities	0.080	Gaussian
		Distance from the airport and railway	0.123	Small
Access	171.0	Distance from high-risk areas	0.140	Large
		Access to bus lines	0.077	Small
		Access to the bus station	0.127	Small
		Access to the fire station	0.291	Small
		Access to transportation lines	0.189	Small
		Access to postal centers and postal services	0.057	Small
		Access to power lines	0.114	Small

In the physical-structural sub-criteria, functional zone of the city, and the accessibility sub-criteria, access to fire stations had the greatest impact on resilience.

In the present research, a map of the effective criteria in resilience was presented, and each of these maps was obtained from the combination of the Euclidean distance layer, fuzzy operators, and the weights obtained from the fuzzy network analysis model. It clarifies the effect of criteria on resilience. The socio-economic criterion map, which is the result of the combination of seven sub-criteria (information layer), indicates that the lands located in the coastal areas and the commercial center of Bandar Abbas have good resilience in its commercial-residential context. After that, the lands located in the east of Bandar Abbas have medium resilience (phase weight 0.5). Nonetheless, from the ecological point of view (four ecological sub-criteria), the lands located in the northwest, northeast, and east of Bandar Abbas are more resilient than other areas. (Figure 2. The weight of socio-economic and ecological criteria in resilience).

The physical-structural criterion, which is the result of sub-criteria of the functional zone, urban uses, and urban infrastructure, the majority of urban lands of Bandar Abbas, from the point of view of this criterion, have a suitable resilience against disaster, except the Payambar Aazam town which is located in the northwest. Regarding physical criterion, which is the result of the slope, topography, geology, earthquake, flood, and fault, the lands located in the eastern part of Bandar Abbas have a good situation in terms of resilience due to the presence of suitable height and slope, geological formations of sediment deposits Quaternary, the distance from the northern active fault, and staying away from floods (Figure 3. The weight of physical-structural and physical criteria in resilience). Finally, the map of access criteria, which is the result of seven sub-criteria (information layer), including access to urban infrastructure, was prepared, and its results demonstrated that, except for the northwestern areas, other lands of Bandar Abbas have good resilience.

For each fuzzy operator, a combined map was obtained from all criteria and sub-criteria. The map obtained from fuzzy AND sharing illustrated that the lands located in the northeastern part of Bandar Abbas have the highest weight; that is to say- these lands have the most resilience against environmental crises. Nonetheless, regarding the fuzzy community of OR, the lands located in the old and commercial context near the wharf have the most resilience (Figure 4. Weight of accessibility criteria in resilience).

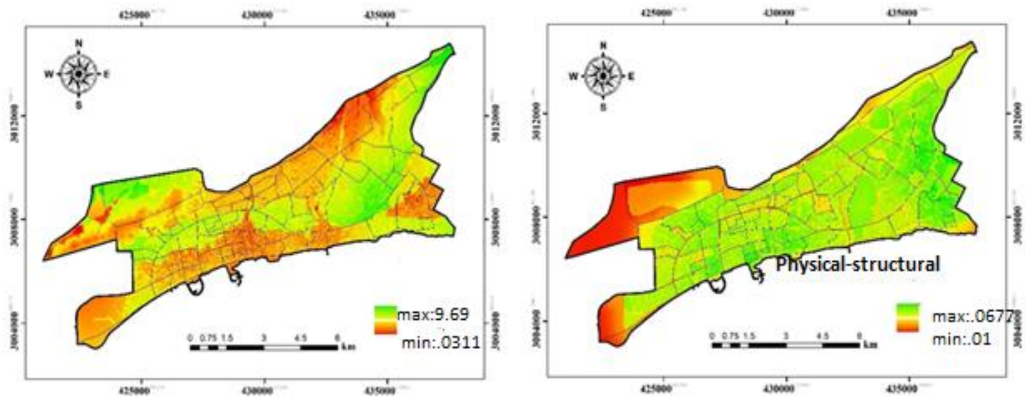

Figure 3. Weight of physical-structural and physical criteria in resilience

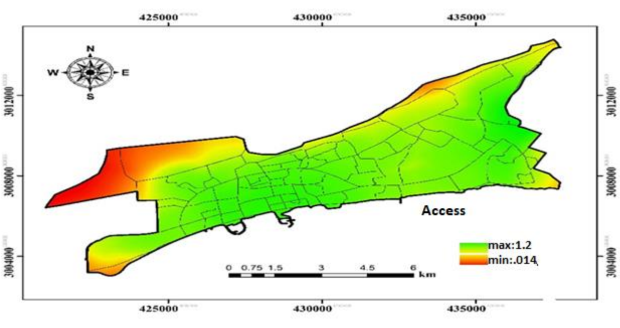

Figure 4. Weight of accessibility criteria in resilience

The results of combining the layers of the research with the fuzzy operator product indicate that the lands located in the eastern part and limited lands in the western region of Bandar Abbas are the most resilient. However, regarding fuzzy operator SUM, most of the lands in Bandar Abbas have good resilience against the disaster (Figure 5). Map of superimposition of criteria with fuzzy operators Product and SUM Gamma operators were also used to superimpose layers of information, based on gamma 0.9 and 0.7, the eastern lands and central areas of Bandar Abbas have the most resilience against the disaster (Figure 5).

Figure 6. Superimposition map of criteria with fuzzy gamma operators of 0.7 and 0.9.

Finally, the 0.5 gammas fuzzy operator was used to superimpose information layers. Its results indicated that the lands in the eastern and western neighborhoods of Bandar Abbas have the most resilience against environmental crises (Figure 7). Table 2 displays the resilience correlation between fuzzy superposition operators and research criteria using OLS regression analysis. To select the best fuzzy operator to evaluate the resilience of neighborhoods against environmental crises in Bandar Abbas city, Least Squares (OLS) regression was used. The results illustrated that among the superimposed maps obtained from the fuzzy operators, the gamma fuzzy operator 0.5 has the highest correlation and relationship with the current research criteria. Therefore, the map obtained by combining all criteria and sub-criteria of the research with fuzzy gamma operator 0.5 is the best map showing the resilience of localities against environmental crises.

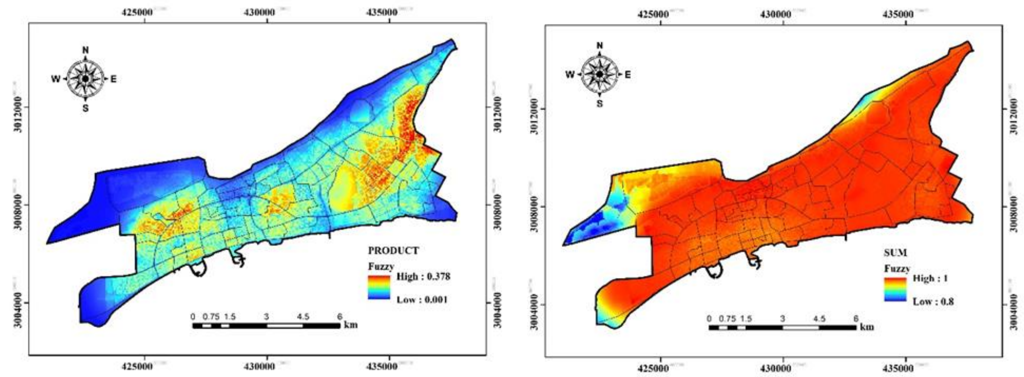

Figure 5. Map of superimposition of criteria with fuzzy operators Product and SUM

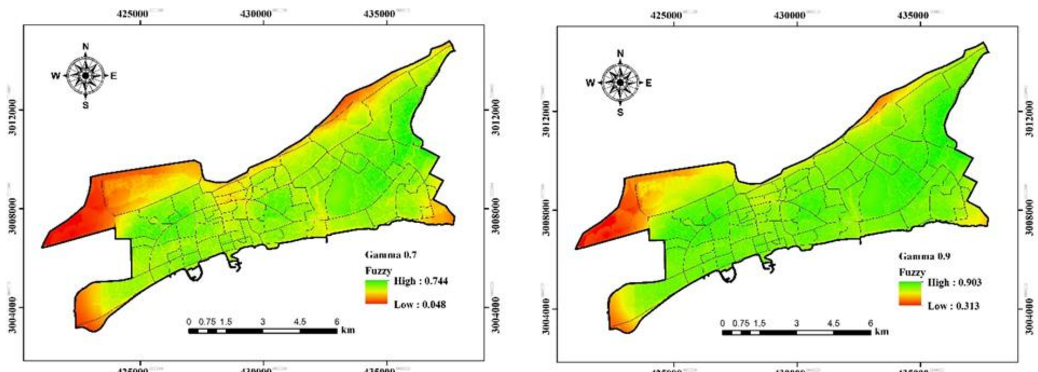

Figure 6. Superimposition map of criteria with fuzzy gamma operators of 0.7 and 0.9

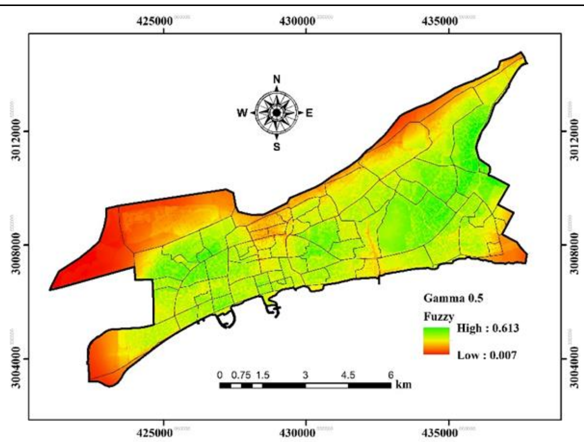

Figure 7. Map of superimposition of criteria with 0.5 gamma fuzzy operators

Table 2. Resilience correlation between fuzzy superposition operators and research criteria with OLS regression analysis

Fuzzy operator	Criterion				
	ecological	Socio-economic	physical	Physical-structural	Access
Gamma 0.9	0.265	0.036	0.126	0.194	0.160
Gamma 0.7	0.511	0.100	0.250	0.358	0.257
Gamma 0.5	0.556	0.114	0.289	0.392	0.249
SUM	0.002	0/027	0.014	0.019	0.025
Product	0.401	0.079	0.236	0.303	0.146
AND	0.936	0/082	0.062-	0.297	0.257
OR	0.172	0.830	0.048	-0.125	0.049

Table 2. Resilience correlation between fuzzy superposition operators and research criteria using OLS regression analysis.

After choosing the optimal operator to identify the resilience of Bandar Abbas against environmental crises, the TOPSIS technique was used to rank the most resilient neighborhoods. The results showed that the localities of Tawheed, Damai, Golshahr North, behind Tarbiat Moalem and Hormzan are ranked from one to five, respectively, and have the most resilience against environmental crises. Nevertheless, the villages of Shir Aol, Seng-Keni, Shir II, 20 meters of Shahid, and Old Soro have the lowest resilience (Table 3).

In the final step of the current research, the classical K-means method was used to cluster the neighborhoods in Bandar Abbas based on their resilience against environmental crises. Its results showed that the eastern, central, and coastal areas of Bandar Abbas have very high resilience against disaster and were placed in the first cluster. In the second cluster, there are eastern and northeastern areas with high resilience. In the fourth cluster are the neighborhoods of Nakhel Nakhda, Qureshi, Seng-Keni, Tree Sabz, Chahestani, Shahnaz, and Isini, which have the least resilience (Figure 8).

Table 3. Resilience ranking of neighborhoods in Bandar Abbas using the TOPSIS technique

District	Distance from the positive ideal	Distance from the negative ideal	Relative proximity to the positive ideal	Resilience rating
Tawheed town	0.017	0.390	0.959	1
Damai	0.018	0.382	0.956	2
North Golshahr	0.018	0.391	0.955	3
Behind teacher training	0.019	0.387	0.953	4
all the time	0.026	0.356	0.932	5
Old airport	0.029	0.357	0.925	6
Paradise of the port	0.029	0.353	0.924	7
Four hundred devices	0.033	0.335	0.912	8
Koi Mellat	0.034	0.330	0.907	9
February 22	0.036	0.327	0.902	10
Six hundred devices	0.035	0.322	0.901	11
police station	0.036	0.319	0.900	12
two thousand and five hundred	0.037	0.321	0.898	13
Amirabad	0.037	0.315	0.894	14
Two thousand	0.040	0.315	0.888	15
Aryashahr	0.043	0.323	0.884	16
South Gulshahr	0.042	0.310	0.882	17
Sid Kamal	0.042	0.308	0.879	18
Behesht-e-Zahra	0.042	0.302	0.877	19
Paul Khajo	0.43	0.303	0.877	20
They are students	0.045	0.318	0.876	21
Azadgan	0.043	0.302	0.875	22
Zibashahr	0.045	0.312	0.874	23
Imam Reza town	0.046	0.321	0.874	24
Azadshahr	0.046	0.310	0.872	25
Mehrgan	0.045	0.308	0.872	26
Khaja Atta	0.047	0.303	0.866	27
behind the city	0.049	0.312	0.863	28
Nayband South	0.048	0.297	0.862	29
Elahia town	0.050	0.309	0.860	30
Andisheh town	0.049	0.298	0.859	31
Chamran Hall	0.050	0.297	0.856	32
Shahnaz	0.051	0.292	0.850	33
Nayband North	0.052	0.294	0.850	34
high wire	0.054	0.301	0.847	35

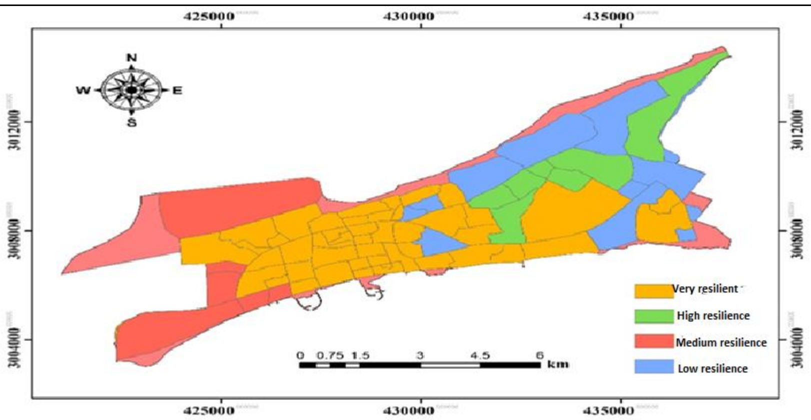

Figure 8. Modeling the resilience of Bandarabss neighborhoods with the classical k- means method

5. Discussion

The results of the present study pointed out that the ecological criterion has the greatest effect on the resilience of Bandar Abbas against environmental crises. This finding is in agreement with the results of the studies by Dadashpour and Adeli (2014), Abdolahi et al. (2016), and Landry et al. (2020). The ecological criterion, which was the result of the risk of pollution and urban green space, is of great importance. As an industrial unit and the special economic zone of the Persian Gulf, Shahid Rajaee power plant is located in the western part of Bandar Abbas. It releases atmospheric pollutants and raw sewage effluent, which severely affects the urban environment. It destroys and leads to the occurrence of an environmental disaster of pollution, the spread of disease, and disturbance in the order of the environmental ecosystems of the region. Therefore, the ecological criterion has the greatest impact on the resilience of Bandar Abbas, especially from the point of view of urban development.

The socio-economic criterion, which ranks second with a weight of 0.236 regarding resilience in Bandar Abbas, is the most important in health centers. If access to a clinic or hospital is easy in a neighborhood, in the event of any disaster, the path to recovery can be found in these centers. The distribution and density of the population have an important role in resilience, and the level of literacy and education of the people, the rate of economic participation, and their awareness and social level are effective in resilience. The physical criterion is in the third rank of resilience; among them, flood risk and slope have the greatest impact on resilience (20). Flood channels lead to the occurrence of floods in the adjacent lands, and the farther the localities are from the channel, the more capable they are of responding to the disaster. Geological formations and faults cause earthquakes. In the lands close to the fault, the probability of earthquake occurrence is high, and it reduces the ability of these lands against disaster.

In Sari, from 1992-2021, the physical development of the city took place due to an increase in population (23). Qazvin also had a growing trend from 1986-2011, and in the meantime, the population factor of 58.36% and the unbalanced urban growth of 41.64% played the most significant role in this development (24). In Tabriz, from 1988-2011, about 5195 hectares were added to the area of the city, and most conversions were related to pasture lands, agriculture, barren lands, and salt fields, which were converted with areas of 3488, 1007, and 484 hectares, respectively. Lands have contributed the most to increasing the size of urban and residential lands (25). In the current study, barren and salt marshlands will have the largest share in the increase of urban lands in Bandar Abbas in 2040, with 1833 and 584 hectares, respectively. In Tehran, from 1385-1374, the largest increase in the area occurred in built-up areas (4603.68 hectares), while the largest decrease pertained to open land (4561.47 hectares) (26).

In Yazd, the prediction of land use in 2020 with the LCM model shows that the largest increase in residential and built-use area is 51.11%, and the largest decrease for barren land is 29% of the forecast (27). In Bojnord, urban land increased from 1529.38 hectares in 2014 to 1837 hectares in 2014. This upward trend will reach 2856.31 hectares in 1410 (17). In Neka, from 1988-2016, forest lands decreased by 2297 hectares, and the most changes were related to the conversion of forest lands to agriculture. The modeling results for 2030 also showed that the forest area will decrease, while agricultural lands and urban areas will increase (28).

In Khorramabad, from 2014-2015, about 943 hectares of built-up land will increase; nonetheless, agricultural land, thin forest, and mountain land will decrease by 279, 549, and 69 hectares, respectively, and will be converted into urban land. To cluster the neighborhoods in Bandar Abbas based on their resilience against environmental crises, the classical K-means method was used. The results pinpointed that the eastern, central, and coastal areas of Bandar Abbas city have very high resilience against the disaster and were placed in the first cluster. In the second cluster, there are eastern and northeastern areas with high resilience.

In the fourth cluster, there are Nakhel Nakhda, Qureshi, Seng-Keni, Sabz tree, Chahestani, Shahnaz, and Isini neighborhoods, which have the least resilience. Environmental crises, such as earthquakes, floods, droughts, air pollution, water pollution, and storms, have the potential to turn into damaging accidents in areas where there is no disaster management and risk reduction. In the present study, the resilience of the neighborhoods of Bandar Abbas against environmental crises was evaluated based on social-economic, physical-structural, access, ecological, and physical criteria. The analysis of this approach was performed using the methods of Fuzzy weighting, fuzzy network analysis, fuzzy superposition operators, and least square regression. Finally, the TOPSIS model was used for ranking, and the classical k-means method was used for locality clustering.

Similar to the results of other researchers, the ecological criterion and the socio-economic criterion displayed the greatest effect in evaluating the resilience of neighborhoods in Bandar Abbas. The least square regression showed that the 0.5 gamma fuzzy operator has the best performance in revealing the resilience of neighborhoods against environmental crises. The neighborhoods of Toheed, Damahi, North Golshahr, behind Tarbiat Moalem and Hormzan, are ranked from one to five and have the most resilience against environmental crises. However, Shir-E Avval, Seng-Keni, Shir-e Dovvom, Bist Metri Shahed, and old Soro areas have the lowest level of resilience, respectively.

6. Conclusion

Bandar Abbas, with a population of over 600 thousand people and an area of 5323.5 hectares at an altitude of 0.6 to 40 meters on the northern coast of the Persian Gulf, is the administrative capital of Hormozgan province. Environmental crises, such as earthquakes, floods, accidents, air pollution, and storms, have resulted in environmental vulnerability and posed severe threats to the security of Bandar Abbas. A thorough understanding of the vulnerability of Bandar Abbas against urban environmental crises will enable policymakers to propose management solutions to reduce vulnerability and risk and increase resilience. Consequently, the main goal of this study was to evaluate the resilience of Bandar Abbas against environmental crises. The results of this study can be of significant help in the decision-making of city managers and the lives of city residents.

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Footnotes

Conflicts of Interest: The authors have no conflict of interests to declare.

References

1. Lin Y, Bie Z. Tri-level optimal hardening plan for a resilient distribution system considering reconfiguration and DG islanding. *Appl Energy*. 2018;**210**:1266–79. doi: 10.1016/j.apenergy.2017.06.059
2. Yadollahnia H, Rajaei SA, PurAhmad A, Khorasani MA. The effects of physical expansion on the environmental resilience case study: City Babol. *J Geogr.* 2021;**19**(69):131-50.
3. Soto Caro M, Leon Canales J, Escobar Gueguen A. Public space and urban resilience: children's perspectives. The case of the hills of Valparaíso, Chile. *Child Geogr.* 2022;**20**(2):206–19. doi: 10.1080/14733285.2021.1925633.
4. Asadzadeh A, Kötter T, Zebardast E. An augmented approach for measurement of disaster resilience using connective factor analysis and analytic network process (F'ANP) model. *Int J Disaster Risk Reduct.* 2015;**14**(4):504–18. doi: 10.1016/j.ijdrr.2015.10.002.
5. Suárez M, Gómez-Baggethun E, Benayas J, Tilbury D. Towards an urban resilience index: a case study in 50 Spanish cities. *Sustainability*. 2016;**8**(8):774. doi: 10.3390/su8080774.
6. Kabir MH, Sato M, Habbiba U, Yousuf T Bin. Assessment of urban disaster resilience in Dhaka North City Corporation (DNCC), Bangladesh. *Procedia Eng*. 2018;**212**:1107–14. doi: 10.1016/j.proeng.2018.01.143
7. Najafi M, Khankeh H, Soltani A, Atighechian G. Reliability and Validity of Household Disaster Preparedness Index (HDPI). *Iran Red Crescent Med J.* 2020;**22**(12).8. doi: 10.32592/ircmj.2020.22.12.281.
8. Zhang X, Song J, Peng J, Wu J. Landslides-oriented urban disaster resilience assessment—A case study in ShenZhen, China. *Sci Total Environ.* 2019;**661**:95–106. doi: 10.1016/j.scitotenv.2018.12.074. [PubMed: 30665136].
9. Fakhruddin BSHM, Reinen-Hamill R, Robertson R. Extent and evaluation of vulnerability for disaster risk reduction of urban Nuku'alofa, Tonga. *Prog Disaster Sci.* 2019;**2**:100017. doi: 10.1016/j.pdisas.2019.100017.
10. Moghadas M, Asadzadeh A, Vafeidis A, Fekete A, Kötter T. A multi-criteria approach for assessing urban flood resilience in Tehran, Iran. *Int J disaster risk Reduct.* 2019;**35**:101069. doi: 10.1016/j.ijdrr.2019.101069.
11. Govindarajulu D. Strengthening institutional and financial mechanisms for building urban resilience in India. *Int J Disaster Risk Reduct.* 2020;**47**:101549. doi: 10.1016/j.ijdrr.2020.101549.
12. Chen C, Xu L, Zhao D, Xu T, Lei P. A new model for describing the urban resilience considering adaptability, resistance and recovery. *Saf Sci*. 2020;**128**:104756. doi: 10.1016/j.ssci.2020.104756.
13. Rezaei MR, Rafieian M, Hosseini SM. Measurement and evaluation of physical resilience of urban communities against earthquake (Case study: Tehran neighborhoods). *Hum Geog*r. 2015;**47**(4):609-23. doi: 10.22059/JHGR.2015.51228.
14. Dadashpour H, Adeli Z. Measuring resilience capacities in Qazvin urban complex. *JOEM*. 2015;**4**(2):73-84.
15. Soltani A, Alaedini F, Shamspour N, Marzaleh MA. Hazard Assessment of Iran Provinces based on the Health Ministry Tool in 2019. *Iran Red Crescent Med J.* 2021;**23**(1). doi: 10.32592/ircmj.2021.23.1.204.
16. Delake H, Samare Mohsen Beigi H, Shahivandi A. Evaluation of social resilience in urban areas of Isfahan. *J Sociol.* 2017;**4**(9):227-52. doi: 10.22080/SSI.2017.1565.
17. Moradpour N, Pourahmad A, Hataminejad H, Ziari K, Sharifi A. An overview of the state of urban resilience in Iran. *Int J Disaster Resil Built Environ*. 2022;**14**(39). doi: 10.1108/IJDRBE-01-2022-0001.
18. Shokri Firoozjah P. Spatial analysis of resilience of babol's regions to environmental hazards. *PSP*. 2017;**4**(2):27-44.

19. Abdollahi A, Sharafi HA, Sabahi GY. Measurement And evaluation Resiliency Institutional and physical-environmental Urban communities to reduce natural disasters, Earthquake(Case study: Kerman city). *EBTP*. 2018;**42**(11):165-87.
20. Pashnezhad Sielab E, Rafieyan M, Pourtaheri M. Spatial Assessment of the relationship between environmental vulnerability and rural community resilience in east-azerbaijan province. *JRRP*. 2017;**6**(2):93-107. doi: 10.22067/JRRP.V6I2.57081.
21. Pour Mohammadi MR, Hadi E, Hadi E. Explaining the socio-economic aspects of urban resilience against earthquake: a case study, 4th district of Tabriz. *Disaster Prev Manag Know*. 2019;**9**(1):78-89.
22. Ghasem F, Shahriar K, Manijeh GT, Patel N. Effects of climate change on dynamics of agricultural lands and cultivation pattern, a case study of Urmia County, Iran. *Arab J Geosci*. 2022;**15**(21):1-1. doi: 10.1007/s12517-022-10926-5.
23. Parkouhi SV, Ghadikolaei AS. A resilience approach for supplier selection: Using Fuzzy Analytic Network Process and grey VIKOR techniques. *J Clean Prod.* 2017;**161**:431–51. doi: 10.1016/j.jclepro.2017.04.175.
24. Liu D, Qi X, Li M, Zhu W, Zhang L, Faiz MA, et al. A resilience evaluation method for a combined regional agricultural water and soil resource system based on Weighted Mahalanobis distance and a Gray-TOPSIS model. *J Clean Prod*. 2019;**229**:667–79.
25. Zhang W, Su S, Wang B, Hong Q, Sun L. Local k-NNs pattern in Omni-Direction graph convolution neural network for 3D point clouds. *Neurocomputing*. 2020;**413**:487–98.
26. Asgarian A, Jabbarian Amiri B, Alizadeh Shabani A, Feghhi J. Assessing urban growth patterns in Sari using landscape ecology approach. *J Nat Environ.* 2015;**68**(1):95-107.
27. Ghaderi Z, Aslani E, Beal L, Dehghan Pour Farashah M, Ghasemi M. Disaster-resilience of small-scale tourism businesses in the pandemic era: the case of Yazd World Heritage Site, Iran. *Tour Recreat Res.* 2022:1-7. doi: 10.1080/02508281.2022.2119519.
28. Shahabi H. Application of artificial neural network, frequency ratio and evidential belief function models in preparing of flood susceptibility map in Haraz watershed: A plan for urban flood risk studies. *JUPM.* 2021;**12**(45):181-202. doi: 10.30495/JUPM.2021.4245.