Ranking Urban Residential Areas Against Earthquake Hazards Using Shannon Entropy AND Topsis Techniques (Cace Study: Amol City)

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Introduction

Vulnerability is the social and economic tolerance of a society against environmental hazards. Accordingly, vulnerability is the extent to which a community can respond to and deal with environmental hazards [19].

The need to reduce the earthquake's vulnerability of the city is one of the main goals of urban planning and design. In order to reduce the vulnerability of urban buildings to earthquakes beside the possible occurrence of earthquakes, it is necessary to assess the vulnerabilities of urban areas [4, 5, 11, 15, 25]. In this regard, different conditions are simulated before the occurrence of possible earthquakes in different intensities and based on that, zoning maps of vulnerabilities of urban buildings are prepared and evaluated [5, 11]. Accordingly, entropy is an approach used to deal with disorder, instability, confusion, and doubts in a system [2].

Shannon entropy is a measure of the degree of uncertainty in the information content of a parameter that calculates the effect of each parameter on the system results [8, 10, 20, 21, 22, 24].

The TOPSIS method is used to rank and select the best option and to determine the distances between the options and their grouping [1, 6, 7, 9, 13, 16, 17]. One of the advantages of this method is that the criteria or indicators used for comparison can have different units of measurement [3, 12, 14, 18, 23, 26].

Proposed Method

Shannon Entropy

Shannon entropy is a function of the probability distribution and a criterion for measuring the degree of uncertainty in the information content of a parameter. By considering the frequency of subgroups' occurrence of that parameter, it

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indicates the level of heterogeneity and consequently calculates the effect of each parameter on the system results. [10, 24].

TOPSIS

TOPSIS method or **t**echnique for **o**rder **p**erformance by **s**imilarity to **i**deal **s**olution is a multi-criteria decision making (MCDM) method. This method can be used to rank and compare different alternatives and select the best one and to determine the distances between alternatives, as well as to group them. [1, 6, 7, 9, 13, 16, 17]. One of the advantages of this method is that the criteria or indicators used for comparison can have different units of measurement and have a negative and positive nature. In other words, combination of negative and positive criteria can be used in this method [3, 12, 14, 18, 23, 26].

Results

In this study, at first, the spatial layers of the study area were prepared from different sources, including the Institute of Geophysics (University of Tehran), Statistics Center of Iran, Geological Survey, Housing and Urban Development of the Mazandaran province, Amol Municipality and Regional Water Organization. This information was then implemented in the GMT software environment.

These spatial layers were the energy released by the earthquakes (last 20 years in terms of tone TNT per area), the quality of buildings and structures, residential density, building density, population density, and permeability of the road network, urban open space and groundwater depth. After implementing these layers in the city map, a decision matrix was created using the TOPSIS method. This matrix was then normalized and scaled. The MatNorm decision matrix is parametric and must be quantified. For this purpose, the weights for each index were determined. In this regard, Shannon entropy method was used for weighting. Using the relationships presented in Shannon's entropy theory, entropy values were calculated for the effective parameters in the study area.

After weighting the normalized matrix, the positive ideal and negative ideal solutions were determined and the distance from the positive and negative ideals was determined and finally, we were ranked the areas by calculating the scores.

According to the TOPSIS method ranking, District 24 with coefficient of proximity (0.903), District 13 with coefficient of proximity (0.727) and then District 18 with coefficient of proximity (0.694) are the most vulnerable areas of Amol city against earthquakes. .

After the area rankings were implemented on the city map in GMT software, the areas were labeled based on proximity to the ideal (Figure 1).

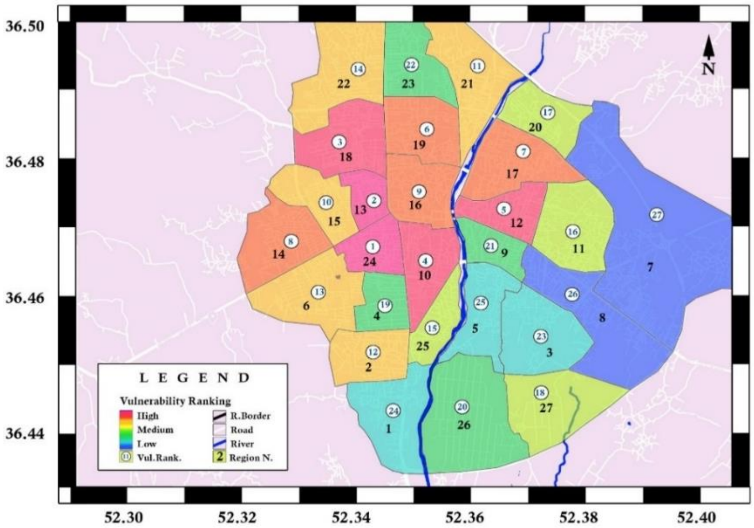

Fig. 1. Earthquake vulnerability ranking of 27 areas of Amol city

Conclusion

According to the zoning of the areas using Shannon entropy, the ranking of the areas, and the distance to the ideal, obtained by the TOPSIS model, and finally, the mapping of the zoning map in GMT environment, the vulnerable areas of Amol city were determined. The results showed that the central areas, i.e. 24, 13, 18, 10, and 12, are very vulnerable. Moreover, areas 19, 17, 14, and 16 are highly vulnerable, areas 15, 21, 2, 6, 22, 25, 11, 20, 27, and 4 have moderate vulnerability, areas 26, 9, 23, 3, 1, and 5 have low vulnerability, and finally, areas 8 and 7 have very vulnerable to earthquakes, respectively. Therefore, it is expected that the vulnerability of urban areas will be considered in future constructions.

Keywords: Urban Vulnerability, Earthquake, Residential Area, Shannon Entropy, Amol city, TOPSIS.

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Typology and spatio-temporal analysis of environmental hazards in Northern Khorasan province

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Extended Abstract

Environmental hazards cause great human and financial damage to the people of Northern Khorasan province every year. In this research, while introducing different types of environmental hazards in different parts of Northern Khorasan, we aim to classify their issues and problems and to specify the time calendar of each in order to prevent possible damages and crises.

Unfortunately, no research has been done so far that typologically and spatially-temporally analyzes all environmental hazards in different parts of the province. The scope of research includes North Khorasan province. This province with an area of 28434 square kilometers and a population of 863092 people is limited to the Republic of Turkmenistan from the north, Khorasan Razavi province from the south and east, Golestan province from the west and Semnan province from the southwest. This province occupies 1.7% of the area and 1.08% of the population of Iran.

Research materials in this research include: 1- Library resources such as books, articles, dissertations, reports and statistics to extract information on the subject under study, 2- Visual documents including satellite images, Aerial photographs, topographic maps and geological thematic maps. This research has been done by descriptive-analytical method and has been described, analyzed and evaluated based on research in library resources and field research. Due to the importance and incidence of Covid-19 disease, in order to assess its risk in the last three weeks ending August 21, 2020 in the townships of the province, first the adjusted incidence rate in the last week (AIRW1), the penultimate week (AIRW2 and two weeks ago (AIRW3) was calculated and then using the relevant equation, the status of each city in terms of white, yellow and red was determined. Regarding the risk of frost, long-term statistical data of minimum temperature of synoptic and evaporative stations of Bojnourd, Asadli, Aghmazar, Resalat, Shirvan, Cheri, Khosh, Noshirvan and Jajarm were used on a daily scale. To determine the time of onset and end of glaciation, the days were converted to Julius calendar and Minitab and ArcGIS software were used to draw graphs and maps of temporal and spatial distribution of the beginning and end of glaciation.

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Environmental hazards in North Khorasan, according to geophysical trends, environment and formation factor, include natural and human hazards. Natural hazards of this province include 4 general categories of geological, atmospheric, hydrological and biological hazards. Brucellosis (tuberculosis), tuberculosis, hydatid cyst, leishmaniasis, viral hepatitis and infection in the elderly are among the most common infectious diseases in North Khorasan. In addition to the diseases mentioned, kidney stones and cancers (esophagus, stomach and prostate) have significant statistics. The chronological symmetry of compilation of the article with the outbreak of Covid-19 disease and turning North Khorasan province in the red situation, made it necessary to address mentioned issues. In total, from the beginning of March 2020 to the end of August 2020, 8800 positive cases of Covid-19 disease have been registered in the province, which are in between the Bojnourd township with a total of 4527 cases, the highest, and Garmeh township with a cumulative frequency of 179 cases, have the lowest number of patients. The townships of Bojnourd and Shirvan with a score of 5.58 and 4.26 respectively have a red status and the highest risk and the townships of Jajarm and Esfarayen with a score of 1.29 and 1.88 respectively have a yellow status and the lowest risk.

Intentional or potential human hazards in North Khorasan Province have been limited to widespread fires and some civil unrest arising from specific points to upgrade the settlement hierarchy from rural to urban or gain township center . Some of the most important possible unintentional and occurred human hazards in the province include ethnic disputes, group conflicts, technological failures due to ammonia gas leakage in Bojnourd Petrochemical Company, exit of fine dust from Bojnourd Cement Factory, fire risk of fuel tanks of National Petroleum Products Distribution Company in Bojnourd and other cities of the province and road accidents.

From the beginning of 2017 to the end of April 2020, 67 natural hazards including flood, frost, drought, lightning, hail, snow and severe blizzard, shower, damage earthquake, storm, landslide and fall occurred in the North Khorasan province, totaling 18343001 million Rials have damaged agricultural sectors, infrastructure, government and public buildings, residential, commercial, industrial, educational buildings and vehicles. The highest prevalence was related to flood, hail and frost, respectively. The frequency of flood and hail indicates an increasing trend in this statistical period. The total damage from the beginning of 2017 to the end of April 2020 indicates that the townships of Maneh and Semelghan, Bojnourd and Shirvan without taking into account the frequency of hazards, population size and area, respectively are the most vulnerable and the townships of Garmeh, Jajarm and Raz and Jargalan, respectively they were the least damaged townships. In terms of the extent of the affected areas and their importance, the frost every year causes a lot of damage to gardeners and farmers in North Khorasan. Frostbite in this province comes in two forms, early and late. Studies have shown that the geographical distribution of the beginning and end of glaciation in North Khorasan province more or less follows the topographic situation of the region. The frequency of damage earthquakes indicates the relative continuity of tectonic movements in the seismic state of North Khorasan. This state, which includes the sedimentary-structural zones of Kopetdagh-Hezarmasjed and Aladagh-Binalood, is affected by the compressive movement of the Turan and Central Iran plates. The “Landslide” slope process is another common hazard in North Khorasan, which is affected by the lithological conditions of its formations, especially the sensitive and slippery formation of Shurijeh (Ksh).

Due to the number of dead, injured, and damaged housing units, Bojnourd, Raz and Jargalan, Maneh and Semelghan townships were the most dangerous and Farooj and Garmeh townships were the least dangerous townships in the province against floods and earthquakes. Regarding the time calendar of hazards in the province, some hazards such as earthquakes and technological failures are not limited to a specific time, and upside down, some such as flood, plant disease, hail and lightning occur at specific times.

The results show that geographical location, environmental conditions and spatial planning system make the occurrence of environmental hazards in Northern Khorasan province inevitable and different regions of this province damage from 51 environmental hazards in the form of 4 general types of natural hazards includes geological, climatological, hydrological and biological hazards and two intentional and unintentional human hazards. This situation requires increasing the safety factor of habitats and activities and modifying and changing the methods and instructions by the relevant agencies to deal with these unexpected events. Harmonization of farmers' lives and activities with frost conditions and geographical compatibility with the Corona virus is suggested as the best biological solution.

Keywords: Environmental hazards, Hazard typology, Spatio-temporal analysis, Northern Khorasan.

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An investigation on effective dimensions and indicators in measuring resilience of historic-commercial urban fabrics against earthquake hazards with a special view to traditional Bazaars

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Introduction

To determine the status of resilience, a wide range of subjects should be considered and studied. For this purpose, at first, the presented resilience models should be evaluated. Amongst the existing resilience models, in Baseline Resilience Index Conditions (BRIC) model introduced by Cutter et al. in 2010 [1], community resilience is categorized into five dimensions: social, economic, institutional, infrastructural, and community capital. In Climate Disaster Resilience Index (CDRI) model introduced by Shaw et al. in 2009 [6], five main dimensions of resilience are introduced as social, economic, institutional, physical, and natural. MCEER report [5] introduced a resilience model named PEOPLES, which evaluates resilience of communities in seven main dimensions of population and demographics, environmental/ecosystem, organized governmental services, physical infrastructures, lifestyle and community competence, economic development, and social/cultural capital. In 2015, Khazaei et al. [2] introduced effective indicators of resilience in five dimensions of legal and institutional, awareness and capacity building, critical services, infrastructure resiliency, development planning regulation, and risk mitigation using Disaster Resilience Index model (DRI). Ostadtaghizadeh and Ardalan [4] have also studied the effective indicators in disaster resilience of communities in Tehran in six dimensions: institutional, economic, cultural, social, physical, and environmental. Thus, the main and common fields of resilience are physical, economic, social, and institutional dimensions; which were previously introduced by Bruneau in 2003 [7].

On the other hand, the consequences of destructive earthquakes such as Bam (Iran, 2003), Sumatra (Indonesia, 2004), Tohoku (Japan, 2011), and many other cases have depicted that the occurrence of natural disasters usually affects valuable historical fabrics, including traditional Bazaars. However, the existing models introduced above cannot be utilized to assess the resilience in these historic and cultural urban fabrics. Therefore, due to the special characteristics of

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traditional Bazaars, it is necessary to develop appropriate models based on specific characteristics of these urban fabrics. In such models, different characteristics of bazaars such as type, age, and importance of buildings from a physical point of view, population density in different hours and delinquency rate from a social perspective, ownership, wealth density, and valuable goods from an economical point of view, and social capital from cultural perspective should be formulated. Besides, historic commercial parameters should be also considered.

Material and Method

In this paper, a set of indicators were selected to evaluate the resilience of traditional bazaars. Some of these parameters were chosen from the previous general resilience models and other related indicators. After eliminating duplicated or overlapping items, 136 indicators were selected and classified into five categories. Then a questionnaire was prepared based on this list and was distributed amongst the relevant specialists to evaluate the importance of each indicator. Based on the results, those indicators that the level of agreement for them was 50% or more were chosen for entering into the final list of indicators. At this stage, by removing 50 indicators from 136 indicators, 86 items remained. By merging a number of them according to their similarities, the final number of indicators was reduced to 50 in five dimensions: physical, economic, social, and institutional, historical-cultural aspects. To determine the weight of dimensions, indicators, and sub-indicators, a questionnaire-based survey was conducted. For this purpose, 45 experts in relevant fields were selected. Then, based on the results and by using Analytical Hierarchy Process (AHP), the weight of indicators and sub-indicators were determined, accordingly.

Weights of Selected Indicators

The social aspects of resilience in Bazaar were introduced as the most important dimension from the perspective of the first group of specialists (university professors) and the physical dimension was selected by the second group (professional experts). The physical and economic dimensions were also chosen as the most important aspects based on the opinion of the third group (graduate students in the relevant fields). By calculating the final weights, it was observed that the social, physical, and economic dimensions are the most important, respectively.

In the physical dimension, almost all three groups selected the vulnerability of buildings as the most important index. Therefore, the final weight of 62.2% has been calculated for the vulnerability of the buildings index. Similarly, in the economic dimension, the economic value of the business with a weight of 71.1% has the highest degree of importance among the three economic indicators. Unlike the previous two dimensions, in the institutional dimension, this agreement was not observed among the three groups. Therefore, the strength and diversity of organizational structures index with a final weight of 36.8% has been identified as the most effective index among the four institutional indicators. Among the social indicators, the preparedness level index and the population structure index with the final weights of 37.6% and 31.1% were selected as the most important indices in the model, respectively. In the cultural-historic dimension, the index of cultural values with a final weight of 47.2% was the most effective.

Figure 1 shows the final weights of the most effective indices of the resilience in historic-commercial urban fabrics. Prioritization of sub-indices based on their weights shows that the most effective factor in the resilience of these fabrics against earthquakes is the building use indicator with a weight of 11.3%. Indicator of building use is a criterion that shows the type of activity of each unit, including commercial (textiles, bags and shoes, carpets, jewelry, paint and glue, cosmetics, food, home, and industrial equipment and ....), warehouse, school, religious, and residential use. Then sub-indicators such as the economic value of property and goods, adaptability and dynamics for post-earthquake recovery, improvement and retrofitting of buildings in each zone, previous experiences and preparedness, belief and sensitivity to earthquake risk and willingness to pay to earthquake risk reduction, per capita income level compared to the city average, training on risk reduction, the vulnerability of road network have the highest degree of importance in the resilience model. The total weight of nine indices mentioned above is equal to 0.532, which is more than 50% of total weight coefficients of 50 sub-indices introduced in the model.

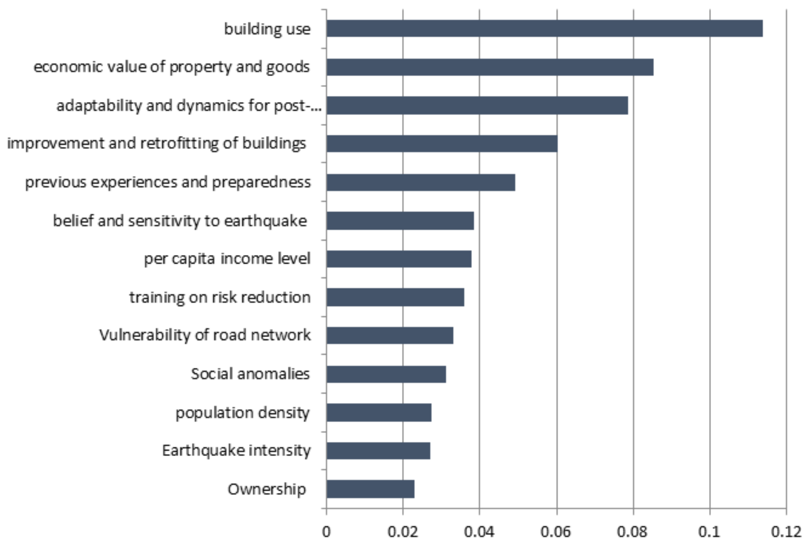

Fig. 1. Ranking of first 13 resilience sub-indicators based on the final weights

Conclusion

This paper presents new indicators for assessment of resilience in traditional bazaars, as important historic – commercial urban fabrics. It was depicted that many indicators and sub-indicators should be considered for the resilience assessment of these fabrics; some of them may not be considered in ordinary urban fabrics. The degree of importance of each dimension, indicator, and sub-indicator from perspective of three different groups of experts was somewhat different, which is mostly due to their attitude to the concept of resilience. Therefore, a combination of different opinions was considered to determine the impact factor and weight of each item. The conducted survey also depicted that the social dimension has the highest weight in the resilience of traditional Bazaars. Therefore, investment in improving social conditions may have the best efficiency in promoting the resilience of these fabrics to natural disasters such as earthquakes. Accordingly, the priorities for interventions in these fabrics can be determined. This may reveal also how to allocate funds to promote resilience in these fabrics, appropriately.

The results of this study also showed that focusing solely on improving specific dimensions of resilience or merely focusing on improving physical indicators (such as reducing the vulnerability of buildings) is not necessarily the best option for improving the resilience of traditional Bazaars. Furthermore, it should be considered that the rehabilitation of historical urban fabrics often faces many complexities due to the historical and cultural value of those fabrics that cannot be changed, easily.

Keywords: Resiliency Index, Historical-Commercial Fabrics, Traditional Bazaars, Hazards Management, Earthquake.

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Reconstruction, validation, and establishment of Environmental Distress Scale due to sudden changes in the environment following hazards (Case Study: the 2003 Bam earthquake)

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Introduction

Formation of distinctive and prominent places creates and finds meaning gradually and through repeated human interactions with the environment. In contrast, the occurrence of sudden disasters, such as earthquakes, has the potential to change the environment and damage emotional and symbolic place-based links at the individual and social levels. In order to define human-place relationships, environmental psychologists have proposed various concepts such as place identity, place attachment, and place dependence. For the first time in 2005, Albrecht introduced the concept of environmental distress (Solastalgia) to describe environmental distress caused by sudden changes in the environment following environmental man-made changes. Subsequently, in 2006, Higginbotham et al. Developed environmental distress scale as a quantitative tool in measuring the distress of individuals and communities during negative environmental changes. The present study attempts to reconstruct, validate and establish the environmental distress (Solestalgia) scale in Iran and after the 2003 Bam earthquake.

Materials and methods

In order to conduct research purposes, three main steps including translation and modification of the questionnaire, pilot and main study were done. In the first stage, the main questionnaire of environmental distress was translated into Persian by two independent translators who were fluent in key concepts. After evaluation of translations by three experts, and contextual adaptation of the items, it translated and evaluated again in English by another two independent translators. After the necessary corrections, the final text was approved. The content validity of the final questionnaire was evaluated qualitatively and

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quantitatively by five experts. After necessary corrections regarding comprehensibility words, classification of items based on categories and concept coverage, the content validity of the questionnaire in the second stage was evaluated 0.83. In measuring the qualitative impact score, the questionnaire was given to 25 members of the target community. In this section, the difficulty, ambiguity and understanding of tool terms were examined. According to the consensus of the participating community, three vague questions were identified, corrected and expressed in simpler language. Purposeful research sampling method was available through an online questionnaire. In the pilot phase, the questionnaire was completed by 44 native residents of Bam and the discrimination index, coefficient of concordance and acceptability constant were calculated. In the main survey, 784 questionnaires were distributed online. Two hundred and ninety five participants aged 28 to 72 years answered the questionnaire. Finally, the research data were analyzed by exploratory factor analysis.

Discus and Results

According to the internal and discrimination index, out of 79 items of Higginbotham's environmental distress scale, 75 items with the ability to understand, accept and coordinate with each other remained in the test and 4 items were removed. These items were divided into 9 factors based on the exploratory factor analysis. The factors were named according to the consensus of experts. Cronbach's alpha results for each factor and the total questionnaire 0.947. and 0.785 were obtained, indicating high structural validity of the scale. Based on the factor analysis findings and data rotation, 9 main factors with a factor load greater than 0.3 have been obtained, which are: first factor; place attachment (feelings about living in Bam); second factor; Solestalgia (feelings about Bam changes following the earthquake); third factor; The severity and extent of pollution and environmental issues caused by the earthquake and subsequent reconstruction operations; fourth factor; Change of features and shape of the earth after the earthquake; fifth factor; Pollution or disruption of water resources; sixth factor; Environmental issues caused by debris and post-earthquake reconstruction, seventh factor; Changing the natural landscape of the city after the earthquake, eighth factor; Evaluation and perceived impacts of reconstruction, development and its benefits and the ninth factor; The consequences of the earthquake on the survivors health.

Conclusion

The present article has been organized with the aim of developing Iranian versions of the Environmental Distress Scale. The results provide a version with appropriate reliability and validity in measuring environmental distress following an earthquake in Iran, which is a confirmation of the original version

of Higginbotham environmental distress scale. The findings show that in the earthquake situation, while maintaining the original foundation of the main tool, its structure appears in a different format. Due to differences in risk-related factors, environmental impacts, type and scope of destruction, culture, identity, economy and society of Bam, the identified factors have a level of differentiation. The present tool provides experts and decision makers with a more complete understanding of the emotional consequences associated with perceived sudden and negative changes in post-earthquake places. In this way, valuable information can be obtained to help individuals and communities cope with adverse environmental events after an earthquake.

Keywords: Bam, earthquake, environmental distress, hazards, adjustment and development of quantitative tools.

Hazards caused by the concentration of pollutants $PM_{2.5}$ by using Regression Methods and Spatial-temporal Similarity in Order to Impute the Missing Values in their Time Series (Case Study of Tehran)

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Introduction

With the increasing growth of industrialization of cities, air pollution has become one of the serious environmental hazards in the world's largest cities, including Tehran. Due to the undesirable effects of pollutants on the environment and human health, the analysis of air quality data plays an important role in protecting the environment and its hazards and tackling air pollution problems. During the last decade, a large number of air quality control data, involving the concentration of existing pollutants in the atmosphere, have been collected by pollution monitoring stations in different cities of the country, which due to various reasons such as calibration, maintenance, device errors, and processing errors show missing values at different intervals. These missing values caused problems in data analysis and leads to challenges in making decisions based on these data. Missing data is a common problem in time series issues and introducing efficient models and methods for managing this problem in data is an effective step towards decreasing bias and increasing air pollution model power.

Materials and Methods

This paper uses $PM_{2.5}$ pollutant concentration data recorded in 12 air quality-monitoring stations, which are controlled by the air quality control company. Data were collected on an hourly basis from Dec. 7, 2016 to Feb. 27, 2019 through the air quality control site.

The purpose of this paper is to introduce an innovative method based on including spatial correlations between time series related to similar stations from the perspective of time series behavior in imputation of missing information related to each pollution measuring station. In this regard, in the first step, through dynamic time wrapping, the spatio-temporal similarity between the time

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series of $PM_{2.5}$ pollutant concentration of the stations is calculated in pairs. Then, for imputation in each target station, the dependence of those stations with the most similarity of desired station is used. In the second step, the initial complete data is formed by deleting the missing values at each station.

In the next step, with a pattern similar to the main missing data, new missing data is obtained with 10, 15 and 20% of missing data. The fourth step involves implementing and comparing different multiple and single imputation algorithms to fill in the missing data. Finally, the performance of various imputation methods is evaluated by the introduced indicators.

Discuss and Results

In this study, in order to implement multiple imputation algorithms such as predictive mean matching, classification and regression tree, random sample and also implementing different single imputation algorithms such as interpolation methods, observation carried forward last from R-programming language has been used.

Cart imputation method with R-squared of 0.66 and correlation coefficient of 0.8 in 10% of missing values, R-squared of 0.6 and correlation coefficient of 0.76 in 15% of missing values, R-squared of 0.58 and correlation coefficient of 0.75 at 20% of missing values, showed the best performance among multiple imputation methods. It is clear that as the percentage of missing values increases, the accuracy of the evaluation criteria decreases.

Given the obtained results, the predictive mean matching method and the random method showed similar performance and performed worse than the tree regression method.

Based on all three evaluation criteria, the linear interpolation method was better than the other introduced methods. Therefore, among the individual methods for the given data, this method is more appropriate. Also, the spline interpolation method has shown the weakest performance among all multiple and single imputation methods.

Although, compared to the tree regression method, in data with 10% of loss, the linear interpolation method has the highest coefficient of determination and correlation and the lowest error in the evaluation indicators, but it should be noted that the linear interpolation method shows magnificent performance for missing values with low interval, but when the data loss interval increases, for example, in the 20% of missing interval, these methods are not able to provide a good imputation for the lost data and consider a fixed rate or a rate with small variation for all the missing values in each interval.

Conclusion

The existence of missing data in the pollutant concentration time series negatively affects the performance of data analysis in machine learning

algorithms and causes bias. The results have shown that determining the spatio-temporal similarity of stations and using the pattern of similar stations using dynamic time wrapping algorithm in combination with based-regression methods leads to improvement of the model performance with high missing intervals, and the tree regression model is the most suitable method for multiple imputation. Single imputation methods, though fast and simple, are dependent on the interval length of missing in time and their performance depends on the variable under study.

Therefore, the use of single methods in air pollution data with high missing intervals is not recommended. Due to the effect that other factors such as meteorological parameters have on air pollution, in future studies, the accuracy of the model can be increased by adding these parameters.

Keywords: DTW Similarity Criterion, Single and Multiple imputation, PM2.5 concentration, Missing values.

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Spatial analysis of flooded and flood-prone areas and it’s hazards in Nourabad city of Lorestan

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Introduction

Today, environmental hazards and coping with them are among the most important concerns of researchers in the field of environmental planning and crisis management. Meanwhile, the flood phenomenon is one of the most dangerous natural disasters that should be given special attention in crisis management. Floods are considered to be one of the most destructive risks that can cause great damage, so that according to the International Danger Database, floods along with earthquakes and droughts have caused the highest loss of life and property. In Iran, in recent years, floods have caused a lot of damage to various areas, especially urban areas, including the floods of April 2019 that many cities, including cities of Golestan province, Lorestan and it covered Khuzestan and caused extensive destruction and great damage to these cities. According to the Lorestan governor's office, the damage caused by the floods in April 2019 was more than 100,000 billion IRR, and 15 people lost their lives due to the floods. Meanwhile, Nourabad city has also suffered a lot of damage, including the destruction of 5,000 residential units and 16,000 hectares of agricultural and garden lands. Also in Nourabad city, floods have destroyed part of residential areas and infrastructure. Due to the fact that the city of Noorabad has a high potential for flooding and in April 2019 has faced the risk of floods, in this study, flood-identified areas as well as flood-prone areas in the urban area of Nourabad have been identified.

Materials and Methods

In this study, in order to identify flooded areas and areas prone to floods, a digital model of 5 m height, 1:50,000 topographic map, Sentinel 1 radar images, information about river discharge, and river roughness coefficient were used as research data. ARCGIS, HEC-RAS and SNAP software are also considered as research tools. In this study, after collecting data and information, the work was done in 4 steps. In the first stage, using Sentinel 1 radar images, the flooded

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areas were identified in April 2009. For this purpose, Sentinel 1 radar images related to before and after the flood were used. In the second stage, field visits have been used in order to adapt and validate the results obtained through radar images. In fact, after the flood, in order to identify the flooded areas through field visits, the direct observation method was used during the flood, the interview and also the review of the available evidence. In the third step, using the HEC-RAS model, flood-prone areas are identified. In the fourth step, the results obtained from the previous steps and the extent of their compliance are evaluated.

Discussion and results

The results of the assessment of flooded areas using radar images indicate that due to the flood in April 2009, many parts of Nourabad city with an area of 0.562 km have been flooded, the northern parts of the city, according to the confluence of the river Gachineh and Badavard have the highest flooding area. In addition, in this research, after conducting field visits, the final limit of flooded areas in Nourabad urban area has been determined, the area of which is 1.212 km. According to the results of field visits, the areas adjacent to Gachineh and Badavard rivers have been flooded, with the highest level of vulnerability to flooding in the downstream areas of Gachineh River, including the surrounding areas of the municipality, as well as areas adjacent to Badavard River. It has been from other areas. In this study, after identifying the flooded areas, using the HEC-RAS method, the areas prone to flooding for different return periods have been identified. , 10, 25, 50 and 100 years old are 0.149, 0.256, 0.564, 0.953 and 1.544 km^2, respectively.

Conclusion

The results obtained through the HER-RAS model indicate that the flood covers a larger part of the city. In fact, since the 100-year return period has been used to compare, the area of the floodplain obtained through the HEC-RAS model, with 1.542 km^2, is wider than the flooded areas identified by radar images. And field visits. Also, the area of flooded areas prepared by radar images (0.562 km^2) is less than the area obtained by other methods, which can be attributed to the flooding on the day of imaging. Evaluating and comparing the results obtained through different methods indicates that the results are consistent, in fact, the areas identified in field visits as flooded areas, In radar images, it has also been identified as a flooded area, and these areas are considered to be flood-prone areas based on the results of the HEC-RAS method, so the results are consistent. The overall results of the study indicate that the city of Nourabad has a high potential for flooding and many of its residential areas, including areas close to the outlet of the Gachineh River, are prone to flooding.

Keywords: Flood, Nourabad, Lorestan, Spatial analysis, Return period.

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