Locating the Establishment of Rescue and Rescue Centers in Nahavand City Using the FAHP Fuzzy-AHP Model

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Introduction

The hazard is an inevitable part of life [1]. Population growth and urbanization have made it necessary to reduce the negative effects of human and social damage on natural and human hazards. Geologically, the county of Nahavand has the coastline near the Gamasiab river basin, which turned Nahavand into a seismic zone [8]. Garon and Nahavand faults were accompanied by a massive earthquake movement, between 1997 and 1963. This county is the most densely populated area in Hamadan province [14]. In Nahavand, most villages are located in the Nahavand Plain due to good agricultural conditions and on the active fault zone of the region. This county has 170 hectares of Worn-out urban texture [18]. Considering above mentioned cases, the need to locate relief and rescue centers in order to maximize coverage of rescue operations in the minimum possible time, far from urban services, is highlighted. Increasing the number of service centers is not due to better service, but the optimal distribution of these centers has a significant impact on the type of operation [20]. However, the location of relief centers for crisis management is one of the few cases that have been dealt with in practice. This research has been carried out with the aim of planning and locating spaces to provide relief and rescue centers in Nahavand earthquake.

Research methods and analysis

The county of Nahavand has an area of 1570 km^2 in the province of Hamedan. The city is located between 48 ° 20 ' and 48 ° 25' longitude, and 34° 0' and 34 ° 5 ' latitude, between high mountains of Zagros and Alvand.

In the present study, two clusters with twelve priority criteria were used to locate these centers. Flood plain, landslides, distances from faults, distance from landslide, drainage networks, soil and geology within the framework of environmental cluster criteria and demographic characteristics (urban centers,

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rural density, rural population), communication networks and land use as the most important human cluster criteria. These criteria are associated with a high population density that meaning more casualties and more damage during an earthquake [11]. Therefore, these centers should be closer to areas with high population density. After preparing the above criteria in the vectorized database, polygon, line, and point data were converted to raster maps in order to be capable to process.

Then the spatial data domain was identified. Using spatial data inputs its matrix is formed to descriptive data based on the suitable and not-suitable of criteria and the fuzzy threshold of each layer. Before the fuzzy layers overlap with the final map, the weights of all layers were obtained to construct the weight matrix of the layers using the Solver AHP Fuzzy software. The weights were standardized by the Chang method and the fuzzy pair comparison matrix was determined. After multiplying the normalized weights in the layers, the layers were overlaying through the Fuzzy sum method. During the analyzation, based on functions and thresholds of fuzzy logic, the data output will map the zones of appropriate locations for the establishment of rescue and rescue centers in the Nahavand earthquake. Finally, the correlation matrix was used to validate the layers and the relationship between 12 criteria of this study by SUM layer.

Result and Discuss

At first, urban centers map, rural centers, communication networks, and village population, and maps of distances from faults, river, and floodplains rasterized according to the incompatibility of the greatest distances. Then, after evaluating the vector layers, geology, soil, land use, and in field, the coding of the layers was determined from 1 to 6 in terms of the coefficient of the significance of each layer. This means that 1 is very important and 6 is the most important. Before layers fuzzification, the fuzzy pair comparison table will be specified. For this purpose, weights of each layer were obtained. So, in the Fuzzy AHP solver software, all weights were defined for the construction of the matrix. The weight of each criterion was then standardized according to Fuzzy Chang, from normalized weights, because the total weights are 1. In the next step, the obtained weight for each criterion in the process of analyzing the AHP network is multiplied in its fuzzy layer and the final value of the areas is obtained .In order to select the appropriate method for maps overlay, the best method that presented the result was the Fuzzy sum operator. The output of the final map was made on five levels. The results showed that 12 percent of the city's area, equivalent to 186 square kilometers, is very suitable for natural and human areas. These centers were seen along the longitudinal plane. The correlation matrix was used for validation. The first layer is the SUM layer and its relationship to the other layer is identified. There is a relationship between all layers that can show the correctness of the model.

Conclusion

The fault map of Hamedan province shows that the concentration of active faults in Nahavand is more than other parts of Hamedan province. Therefore, the present study addresses the issue of locating suitable spaces for the establishment of relief and rescue centers during natural hazards. Then, by providing the criteria and indicators that were the result of scientific and targeted research, the location of these centers was carried out with the view that such environments should be safe and away from high-risk environments with maximum coverage. Locating relief and rescue centers using GIS, and AHP hierarchical evaluation of the combination and the Fuzzy model by overlapping the fuzzy layers based on the suitable and Not-suitable layers. The findings showed that near 12 percent of the area has potential to create these centers, which spread across the plain of Nahavand, and cover the entire plain. Such a specialty for crisis management in this area, which has a great potential for seismicity, can be of great importance, because, in the event of an earthquake, it is possible to quickly provide services to earthquakes.

Keyword: Site selection, Crisis Management, Geographic Information Systems, Earthquake hazard.

References

[1]. Smith Kate (2011) Environmental hazards, Ibrahim Moghimi and Shapoorgoodarzinezhad, Publishers samt.
[2]. Bafandeh Alireza& MahmoodzadehMorteza(1386).Developing a Comprehensive Method for the fuzzy Analytic Hierarchy process(with emphasis on revising fuzzy inconsistency pair wise comparison matrix)Journal of Management Sciences, Vol1, No.2.
[3]. Khan Ahmadi, Marzieh; Mehdi Arabi; Alireza; Vafayinejad Hani Rezaiyan (1397). The location of fire stations using combining Fuzzy and AHP logic in GIS environment (Case study of District 1-District 10 of Tehran). Sepehr Geographic Information Quarterly, Twenty-Third Period, 89, pp. 98-88.
[4]. Rezapur Rafat (1385). Application of Geographic Information System (GIS) in Crisis Management of the Third International Congress on Health, Management and Management of Disaster in Tehran, Medical Association of Tehran.
[5]. Rezai, Mohammad Reza; Ghadeem Rahmati, Zer; Hosseini, Seyyed Mostafa (1393). Location of relief centers in Yazd using FUZZY and GIS network analysis process, Journal of Human Geography Research, Volume 46, Issue 1, pp. 18-29.
[6]. Zand Karimi, Saman; Nayeri, Hadi (1394) Evaluation of Geological and Geomorphological Considerations in Locating Police Places. Office of Applied Research of Kurdistan Police Command, p. 2.
[7]. Sa'idian, Bahram; Mesrari, Mohammad Saeed; Qodousi, Mostafa (1393). Optimization of the allocation of relief and temporary relief centers after the earthquake and allocation of urban blocks to these centers using an over-

genealogy algorithm. Sixth International Conference on Crisis Management, Mashad, Iran, pp. 62-88.
[8]. Shirmard Hojat ؛ Bahroudi Abbass ؛ Adeli Amir (1394) Fuzzy AHP method in GIS for determining the optimal drilling points in the Naisian Porphyry Copper mine, 93 , 24 .pp91-100.
[9]. Taleghani, Mohammad, Shahroudi, Kambiz, Sanei, Farzaneh (2012), Comparative Comparison of Fuzzy AHP and AHP in the Purchasing Preferences (Case Study: Industry), Journal of Operations Research and its Applications, Year ninth, Number One (32nd successive), Spring 91, p. 91 - 81.
[10]. Abedini, Mousa, Fathi, Mohammad Hossein (1393), Sensitivity zoning of landslide hazard in Khalkhal Chai watershed using multi-criteria models, quantitative geomorphology studies, year 2, 4, spring 1393, p. 85-71.
[11]. Abdolahi Majid, (2004) Crisis Management in Urban Areas (Flood and Earthquake), Publications of the Organization of Municipalities, Tehran.
[12]. Azizi, Mohammad Mehdi (2003). Density in Urbanization, Principles and Criteria for Determining Urban Concentration. Tehran, University of Tehran, 198 p.
[13]. Asgari, Ali; Rakhshani; Pedram; Esmaeili Akbar (2012). GIS application in crisis management. Openings, Organization of Municipalities and Villages of the Country, Tehran, 230 p.
[14]. Isavi, Vahid; Karami; Jalal; Ali Mohammadi; Abbas and Niknejad; Seyed Ali (2012);Comparison of two methods of decision making of AHP and AHP-Fuzzy in the initial location of underground dams in Taleghan area, Journal of Geosciences, 2000, P. 85, pp. 27 to 34.
[15]. Kayani, Sajjad; Fotouhi, Samad (1395). Investigation of Sewage Capability of Nahavand Fault. International Journal of Analytical Research of Pure Earth, p. 14, p. 127 to 124.
[16]. Mohammadi Soleimani, Mohammad Reza; Delaware; Ali; Darthaji; Fariborz; Saleh Sedghpour; Bahram; Sanjari; Shahrzad (1393) A Model for Choosing Industrial Industry, Industry, Mining, and Trade Organizations by Using Fuzzy A Php, Quarterly Journal of Educational Measurement 81, year 5.
[17]. Mohammadi, Honey; Zarbast, Esfandiar (2005). Locating relief and rescue centers (in the event of an earthquake) using GIS and Multi-criteria AHP evaluation. The Fine Arts magazine, 21, pp. 16-5.
[18]. Moghimi, Ibrahim (2010). Geomorphology of Iran, Tehran: Tehran University Press.
[19]. Tadbir Shahr Consulting Engineers (2011). Development plan (comprehensive) of Nahavand city, Road and Urban Development Department of Hamedan province, 1st quarter, 152 p.
[20]. Nategh Allah, Fariborz (1379). Managing the earthquake crisis of cloud cities with the approach to Tehran crisis management plan. International Institute of Seismology and Earthquake Engineering, 192 p.
[21]. Hashemininia, Soodabeh, Rezaei Kalantari, Parvin, Manani, Sayedeh Faezeh (1394) Location of Sari Emergency Relay Stations, The first scientific-scientific

congress on modern horizons in the field of civil engineering of architecture, culture and urban management of Iran, Tehran, Iran, pp. 74-92.

[22]. Berberian, M, (1995), Master blind thrust fault hidden under the zagros folds: active basement tectonics andsurface morphotectonics, Tectonophysics, p 241.

[23]. Taibi, Aissa, and Atmani, Baghdad(2017), Combining Fuzzy AHP with GIS and Decision Rules for Industrial Site Selection, International Journal of Interactive Multimedia and Artificial Intelligence, Vol. 4, N6.

[24]. chalenko, J.S. and Braud, J. (1974), Seismicity and structure of Zagros (Iran)-the main recent fault between 33 and 35º N. Philosophical transactions of the Royal Society of London,p 277, 1-25.

Providing a Spatial Approach in the Rescue and Relief Management after the Earthquake

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Abstract

Every year, many human beings suffer from an earthquake as a near-unpredictable natural disaster and its devastating human and financial losses. Management of such crises is related both before and after the crisis. Relief and rescue is only a stage in the occurrence of disasters can be studied in advance of the crisis to provide a solution to improve the performance of relief and rescue teams during the crisis. In this study, using a spatial information system and particle swarm algorithm and simulating a presumptive earthquake, a solution is suggested for optimal management of relief and rescue teams in earthquake. In this method, an earthquake, and 32 relief workers of four operational teams in 148 housing complexes simulated to study area in Tehran. Rescuers, with the help of particle swarm algorithm in a spatial information system, were allocated relief and rescue activities, in less time, would provide relief and rescue more efficient than the empirical mode. The use of this method to optimize simulations, as well as to implement the scientific and practical structure of relief and rescue teams and activities, will be a new way to improve the quality of relief and rescue after the earthquake. The results of the proposed method of this research showed Performance improvements of about twofold.

Introduction

One of the issues that most of the world's major cities face is the issue of natural disasters. The nature of the overwhelming majority of natural disasters and the need for quick and correct decision-making and implementation of operations has created knowledge of "crisis management". This knowledge refers to the set of activities that occur before, during and after the occurrence of disaster, in order to reduce the probable vulnerability caused by the occurrence of these events [5]. It is necessary to carry out all the affairs and actions necessary to

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achieve the goals outlined in the above definition, which requires the assumption of operational roles by operational teams [3]. Given the importance of relief and rescue at the time of natural disasters to save lives and property, the proper allocation of aid workers to activities is necessary.

In order to improve the relief and rescue operation, firstly, activities were carried out at the time of the earthquake, and comprehensive information were obtained on the post-earthquake relief and rescue mode. In order to allocate people, using optimization methods, considering the conditions of this research, is effective in improving the efficiency and effectiveness of post-earthquake relief. Hence, due to the nonlinear relations of this study, and in light of previous research, the particle swarm optimization algorithm was chosen as a suitable method for solving this problem. Moreover, also the use of a spatial information system for modeling, displaying, and updating of force information, activities, and conditions of earthquake area is suitable for optimal forces management [1].

Theoretical Foundations

Relief & Rescue

Review the tasks of the rescuers

This section examines the responsibilities of rescue workers in the earthquake crisis and important points in the earthquake relief process. Some search and rescue actors include four components of locating, evaluating, fixing, and transferring [19]. First, the location and release of individuals and the medical assessment and, if necessary, the use of primary care, emergency treatment (stabilization) and transfer to treatment centers are carried out [26]. The rescue team should have a precise program to carry out rescue operations for those in detention.

Search and Rescue Operations Management

To ensure the success of search and rescue operations in urban areas; it must be done very carefully. The relief and rescue program can be divided into five stages, respectively [26]:

- Primary Identification - Data Collection (Preliminary Assessment)
- Quickly assess the area (Technical Inspection)
- Surface Search and Rescue in the Damaged Area (Primary Rescue)
- Search and rescue by technical means (Secondary Rescue)
- The systematic removal of debris (Final Collapse Lifting)

On the other hand, seven steps in search and rescue operations are assumed to be considered by the savior’s people [9]:

1. Data collection: One of the first steps to be taken is to assess and assess the situation.
2. Evaluation of Damage: By looking at different angles to the buildings.
3. Identifying resources and accessing them: including access to facilities, equipment, and personnel.
4. Priority: Includes emergency diagnosis and safety assurance for the

continuation of search and rescue operations. Sometimes a building should be marked in such a way that no other person enters it and waits for other forces or more facilities.

5. Designing a Rescue Plan: In this section, it becomes clear who and with whom the conditions will enter the building.
6. Guidance for search and rescue operations: Search for people under the rubble remains and caught
7. Evaluate progress: The situation must always be checked to assess the progress of the rescue program and to prevent any damage to the relief forces

Particle Swarm Optimization (PSO)

The first attempt by Kennedy and Eberhart, simulating the social behavior of birds in 1995, presented the particle group optimization method. The components of a group follow a simple behavior. In this way, each member of the group imitates the success of their other neighbors. The purpose of such algorithms is to move members of the group to the search space and to accumulate at an optimal point (such as the source of food).

Methodology

To achieve relief & rescue optimal management, close interaction is being necessary [25]. The results of this study showed that parameters such as the duration of survival under the rubble, the duration, the distance between people and the location of activities, the speed of people when moving to the goal of the relief worker is very important in fulfilling the task. With the studies and studies, finally, the relation one was designed, which is a continuous nonlinear relationship. According to the studies, the method of optimizing the congestion of particle capabilities solves these functions, and this method allocates individuals to activities in this research is optimized:

$$\text{Cost} = (1/\text{MaxInjured}) * (e^{-\text{Search speed} \times \text{Search time} \times \text{Spacing} / \text{Area Assigned}}) \quad (1)$$

In the above relationship, all parameters must follow a unit or reputation [24], “Max Injured” the most injured number among the wounded of each residential building, “Area Assigned” is the area [20], which the same activity is located inside it. “Spacing” the relief distance to the operating area and the “search time” and “search speed” are respectively the duration of the work and the speed of the relief worker. If a rescuer will be sent to a region that is estimated to be several people under debris, the duration of activities will be multiplied by the number of submarines. Moreover, to achieve the final cost of an activity that requires several people, it must be summed of the costs from each who performs that activity.

Result and Discussion

The cased study is a part of the central region of Tehran. The relief and rescue activities of the earthquake crisis include Searching, Light Collapse Lifting, Heavy Collapse Lifting, Primary Helping, Securing, Pointing, Securing Pilot, Air update in the rubble, reconstruction of the network of roads [6, 19]. In this research, 32 relief workers of four operational teams [22], and at the beginning of the operation, they are deployed at the nearest crisis management center to the study area. Figure 1 shows the first study area and the initial position of the relief workers in the study area.

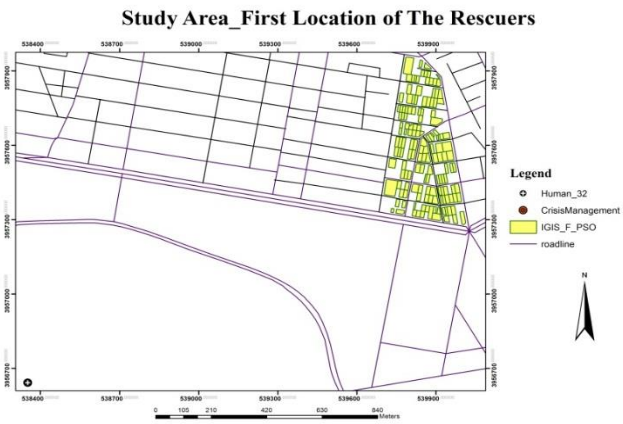

Figure 2: Study area and the first location of rescuers

The following shows building and human damages data showing the initial phase of earthquake simulation, which includes 22 out of 148 damaged sites, and the descriptive information of relief workers in a hypothetical earthquake, in which 14 relief workers out of 32 relief workers, as well as the third, are shown their activities:

FID	Area_Sli	Area_Mod	Area_Ext	PIC	PHC	PKC
0	577.5526	536.0314	503.1371	10.6796	2.088236	2.263707
1	501.299	459.0916	416.5117	2.716489	0.470734	0.470734
2	1026.058	870.5301	785.5003	5.123783	0.887759	0.887759
3	1140.485	967.4026	872.521	23.50837	4.073102	4.073102
4	674.1776	623.9793	567.4219	3.365664	0.583245	0.583245
5	441.3072	432.6968	415.5804	7.608515	1.31905	1.31905
6	2567.228	2362.816	2162.427	20.69483	3.586386	3.586386
7	518.1156	507.9455	463.8571	6.07271	1.052466	1.052466
8	521.1291	483.1575	440.1828	12.3414	2.138707	2.138707
9	514.1301	472.5337	440.5078	12.34885	2.140286	2.140286
10	575.0884	533.4714	486.3073	11.21716	1.98293	2.011816
11	478.2005	454.5031	419.2826	11.29328	1.957294	1.957294
12	551.9115	482.5104	440.7943	8.972257	1.554749	1.554749
13	648.6336	549.9993	495.6867	10.52556	1.823667	1.823667
14	646.905	594.5228	554.0694	11.07337	1.919218	1.919218

Fig. 2. building and human damages

UIDhuman	TypeHuman	Proficiency1	Proficiency2	Proficiency3
001	Rescuer3	Primary Helping		
002	Rescuer2	Primary Helping		
003	Rescuer1		Primary Helping	
004	Savior3	Searching	Pointing	Secuting
005	Savior2	Searching	Pointing	Secuting
006	Savior1	Searching	Pointing	Secuting
007	ISAR	Collapse Lifting	Secuting Pilot	Air Update in the Rubble
008	Rescuer3	Primary Helping		
009	Rescuer2	Primary Helping		
010	Rescuer1	`	Primary Helping	
011	Savior3	Searching	Pointing	Secuting
012	Savior2	Searching	Pointing	Secuting
013	Savior1	Searching	Pointing	Secuting
014	ISAR	Collapse Lifting	Secuting Pilot	Air Update in the Rubble

Fig. 3. Descriptive information of relief workers

Regarding the parameters stated in the method of implementation (i.e.; the descriptive information of the rescuers, the activities and initial damages of the earthquake), the proposed algorithm of this research, is evaluated and calculated by using relations discussed for all the rescuers in all the housing complex**es.** And eventually, the allocated of relief workers to the activities was obtained. An example of the optimal mode of relief and rescue teams is showing in the figure below.

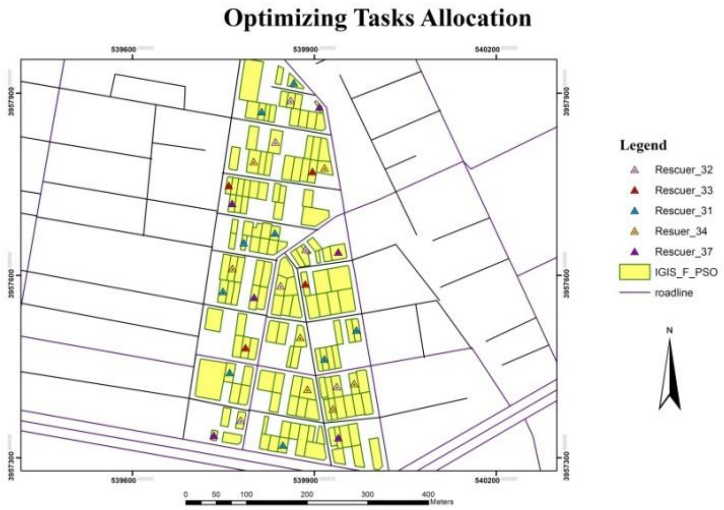

Fig. 4. Optimization of the Relief & Rescue Team

In the study area of the image above, the “Rescuers 34” relate to relief workers assigned to Light Collapse Lifting activities; “Rescuers32”, relief workers, and Pointing; “Rescuers31”, rescuers assigned to Searching activities. As well as “Rescuers33” for rescue workers who are engaged in Securing Pilot and relief workers “Rescuers 37”, engaged in Primary Helping activities. The allocation of people is carried out according to the priority, and the residential areas that have more damage are in the priority of the relief effort.

In evaluating the efficiency of the proposed algorithm, the positive effect of the initial population selection method shown in the results obtained from the implementation of the proposed algorithm. Finally, a 2.2 fold improvement in the results obtained from the state that was not used by this algorithm. In the table below, the calculation of the cost function in the two modes of implementation of the proposed algorithm and its non-implementation is set, which represents the calculating the cost of the allocation in the two situations for the entire operational team.

Table 1. Comparison of the results of the proposed algorithm and its validation

Used model	Cost calculated for the entire operational team
Without using the proposed algorithm	0.564
Using the proposed algorithm	0.252

Conclusion

Due to the facts that the problem is considered to be grouped of the subject of this research, the effectiveness of each person's activity on the other people's activities, and the group and the category of operations, as well as the structure of the particle swarm algorithm, which allows for more repetition in less time, the proposed algorithm of this study is identified as an appropriate solution to the post-earthquake relief and rescue problem.

The structure of the particle swarm algorithm is continuous; because of the discrete structure of the present, it is implemented discretely by applying changes to the structure of this algorithm. As previously stated, the context of individuals, their specializations, the activities, and the damaged sites have the same priorities as those that were implemented in the algorithm.

Using the proposed algorithm of this research and applying the changes expressed in it, in order to optimize and implement the scientific and practical structure of relief and rescue operation activities and teams, is a novel and effective way to improve the quality of relief and rescue after it will be an earthquake. Finally, as shown in Table 1 in the findings, the proposed algorithm implementation in this study improved the 2.2% of the results from the allocation of relief workers to a state that was not used by the proposed algorithm of this study.

For future researches, the optimization methods such as simulated annealing, ant colony, genetics, and game theory are suggested.

Keywords: Relief and Rescue, Spatial, Crisis Management, Earthquake, Particle Swarm Algorithm.

References

[1].Rad, d. Vafaeinejad, A. R. (2016), "Helping to manage the earthquake crisis by locating temporary accommodation centers using a GIS-based decision support system (Case study: District 8 of the Isfahan Municipality)". Journal of Geochemical Science and Technology. Volume 5, Number 2. Tehran. Iran

[2].Sargolzaei, A. Vafaeinejad, A. R. (2018), "Finding the shortest network path using the Cuckoo Optimization algorithm in the spatial information system." Journal of Science and Technology Mapping. Volume 6, Issue 4. Tehran. Iran

[3].Sharifi Sadeh, M. (2012), "Teamwork and teamwork in relief and rescue operations". Institute of Higher Scientific-Practical Higher Education of Iran. Tehran. Iran

[4].Saeedian, B. et al. (2016), "Comparison of the efficiency of genetic and mass fragmentation algorithms for optimal allocation of water to agricultural land under water constraints". Journal of Information Technology Engineering, Vol. 3, No. 4, pp. 19-42

[5]. Abdullahi, M. (2013), "Crisis Management in Areas", Organization of Municipalities and Government Departments. Tehran. Iran

[6].Asgari, A. et al. (2013), "GIS Application in Crisis Management". Organization of municipalities and villages of the country. Tehran. Iran

[7].Mohammadi Yeganeh, Sh. Mamdouh, h. 1385. "Helicopter in search and rescue", Institute of Higher Scientific-Practical Higher Education of Iran. Tehran. Iran

[8].Mazidabadi, Sh. (2004), "Search and Rescue in Collapsed Buildings (Debris)", Nakhl. Tehran. Iran.

[9].Valadbeygi, B. Pourheidari, Gh. (2010), “Coping and Reconstruction in Crisis”. Tehran: Halkan University of Science and Technology Higher Education Institution and Baqiyatallah University of Medical Sciences. Tehran. Iran.

[10]. Izadi, A. (2010), "An overview of the basics of disaster management". Rescue organization. Tehran. Iran.

[11]. Akbari, M., Rashidi, H. (2016), “A Multi-Objectives Scheduling Algorithm Based on Cuckoo Optimization for Task Allocation Problem at Compile Time in Heterogeneous Systems”, Expert Systems with Applications, Volume 60, PP. 234–248. ELSEVIER

[12]. Clerc, Maurice. (2010), “Particle Swarm Optimization”, First published:19 January 2010,wiley online library

[13]. Ghaderi, Abdolsalam et al. (2012), “An Efficient Hybrid Particle Swarm Optimization Algorithm for Solving the Uncapacitated Continuous Location-Allocation Problem”, Networks and Spatial Economics 12(3):1-19 · September 2012.

[14]. Gyeongtaek Oh, Youdan Kim, Jaemyung Ahn, Han-Lim Choi. (2016), “PSO-based Optimal Task Allocation for Cooperative Timing Missions”, IFAC-PapersOnLine, Volume 49, Issue 17, 2016, Pages 314-319. ELSEVIER

[15]. Haowei Zhang, Junwei Xie, Jiaang Ge, Wenlong Lu, Binfeng Zong. (2018), “An Entropy-based PSO for DAR task scheduling problem”, Applied Soft Computing, Volume 73, December 2018, Pages 862-873. ELSEVIER

[16]. Jena, R.K. (2015), “Multi Objective Task Scheduling in Cloud Environment Using Nested PSO Framework”, Procedia Computer Science, Volume 57, 2015, Pages 1219-1227. ELSEVIER

[17]. Lei X., Zhou, X. Z., Li, Q. M., Zhang, X. F. (2016), “Energy-efficient resource allocation for multiuser OFDMA system based on hybrid genetic simulated annealing”, Soft Computing. PP. 1–8. Sprringer

[18]. Lin, J. T., Chiu, C. C. (2015) “A hybrid particle swarm optimization with local search for stochastic resource allocation problem”, Journal of Intelligent Manufacturing, PP. 1–15. Springer

[19]. Mahdjoub, J., Rousseaux F., Soulier E. (2014), “Towards Better Coordination of Rescue Teams in Crisis Situations: A Promising ACO Algorithm”, Information Systems for Crisis Response and Management in Mediterranean Countries, Volume 196 of the series Lecture Notes in Business Information Processing PP. 135-142. Springer

[20]. Mountaineer Area Rescue Group. “Probability of Detection”. Appalachian Search and Rescue Conference

[21]. Nedjah, Nadia. Mathias, Rafael. Mendonça, Luiza. Mourelle, Macedo. (2015), “PSO-based Distributed Algorithm for Dynamic Task Allocation in a Robotic Swarm”, Procedia Computer Science, Volume 51, 2015, Pages 326-335. ELSEVIER

[22]. Rasekh, A., Vafaeinezhad, A. R. (2012), “Developing a GIS Based Decision Support System for Resource Allocation in Earthquake Search and Rescue Operation”, Computational Science and Its Applications – ICCSA 2012, Volume 7334 of the series Lecture Notes in Computer Science PP. 275-285. Springer

[23]. Wei Hong Lim, Nor Ashidi Mat Isa. (2015), “Particle swarm optimization with dual-level task allocation”, Engineering Applications of Artificial Intelligence, Volume 38, February 2015, Pages 88-110. ELSEVIER

[24]. Vafaeinezhad, A.R. Alesheikh, A.A. Hamrah, M. Reza Nourjou, R. Shad, R. (2009), “Using GIS to Develop an Efficient Spatio-temporal Task Allocation Algorithm to Human Groups in an Entirely Dynamic Environment Case Study: Earthquake Rescue Teams”. Computational Science and Its Applications – ICCSA 2009. Volume 5592 of the series Lecture Notes in Computer Science. pp 66-78. 2009.

[25]. Vafaeinezhad, A.R., Alesheikh, A.A., Roshannejad, A.A., Shad, R., 2009. “A new approach for modeling spatio-temporal events in an earthquake rescue scenario”; Journal of Applied Sciences, 9: 513-520.

[26]. Bahrami, N., 2019. “Using Tabu Search Algorithm and Geospatial Information System for Managing of the Relief and Rescue Teams”; Journal of Geomatics Science and Technology (JGST), Volume 8, Issue 3, 179-188.

[27]. Yao Lin Liu et al. (2012), “Rural land use spatial allocation in the semiarid loess hilly area in China: Using a Particle Swarm Optimization model equipped with multi-objective optimization techniques”, Science China Earth Sciences, July 2012, Volume 55, Issue 7, pp 1166–1177. Springer

Rapid Damage Mapping after an Earthquake using Sentinel-2 Images (Case Study: Sarpol-e Zahab)

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Abstract

Rapid damage mapping after an earthquake in order to produce damage map is important for relief and rescue operations. Recently, the use of remote sensing images for producing damage maps is considered due to their synoptic view and low cost. In this research, a rapid damage mapping approach according to change detection is proposed, which is applied to the 2018 Sarepol-e Zahab earthquake. In order to assess results, outcomes of the change detection were evaluated using ground truth, which show high accuracy in detecting change areas. On the other hand, our damage map was evaluated using damage map produced by the European Space Agency (ESA), which outcomes depict our proposed method can detect damage areas by an overall accuracy of 84 %. Using the proposed method, damage map of the Sarepol-e Zahab was generated less than 30 minutes.

Introduction

Remote sensing is a useful science and technology for different applications, especially disaster management. Remote sensing can be used to produce building damage maps after the earthquake. Recently, researchers used remote sensing data for producing building damage maps [1-4]. However, the used approaches are based on training samples. Preparing training samples is a time consuming task. For this reason, scientists would like to develop rapid damage mapping. Tiede et al. proposed a method to map damage areas of the Haiti earthquake using a shadow analysis approach. The proposed approach can produce damage areas after 12 hours [۵]. The main goal of this paper is to develop a rapid damage mapping approach based on pre- and post-event images

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in Sarpol-e Zahab. The developed method benefits from decision making approaches to make a rapid map.

Methodology

The proposed method is done in four steps according to Figure 1. In the first step, some essential pre-processing tasks including georeferencing and radiometric correction are performed. In the second step, difference image is produced and some textural features are extracted from it. In the third step, change and unchanged areas are identified using three change detection approaches. Finally, TOPSIS decision making approach is employed to make a damage map.

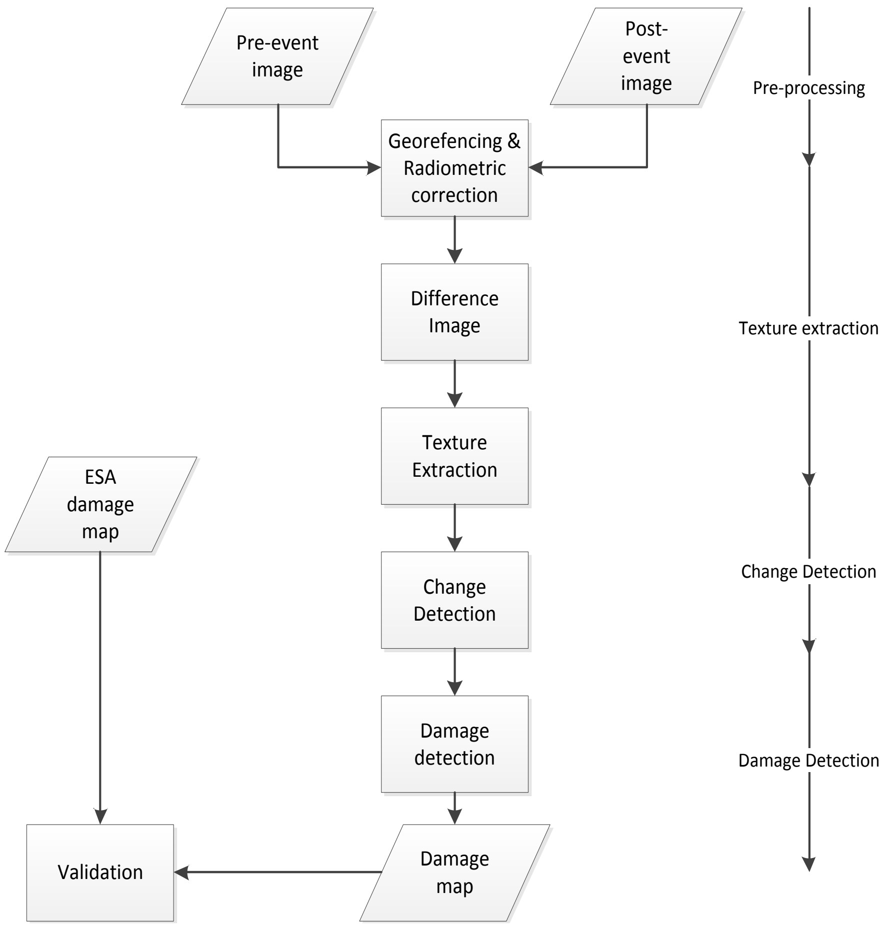
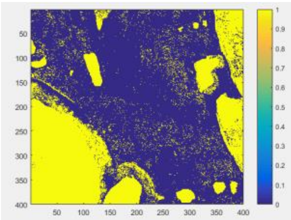


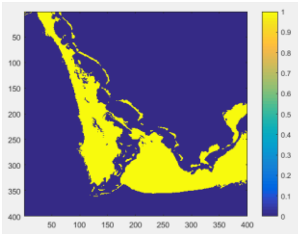
Fig. 1. Workflow of the proposed method

Results

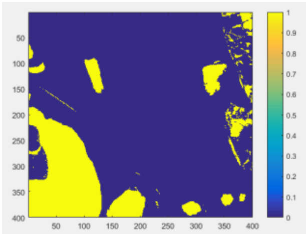
Since the proposed method is based on change detection, we applied it to two data sets. Results of change detection over two case studies present in Figure 2. According to validation results, the proposed approach can detect changed and unchanged areas with about 95 % accuracy.



Spectral angle mapper of Region 1



Nearest neaghbour of Region 2



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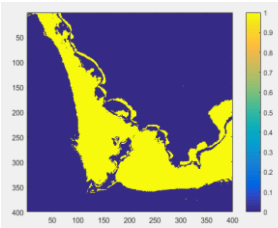
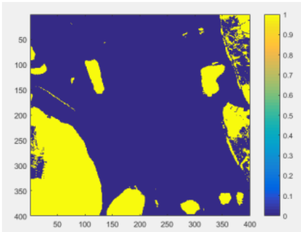


Maximum likelihoo of Region 2



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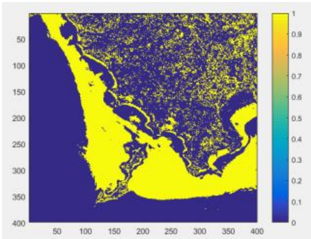

Spectral angle mapper of Region 2

Fig. 2. Results of change detection approaches over two study areas

Using pre- and post-event Sentinel-2 images and our proposed approach, damage map of Sarpol-e Zahab was produced. Figure 3 shows pre- and post-event Sentinel-2 images and damage map of the study area.

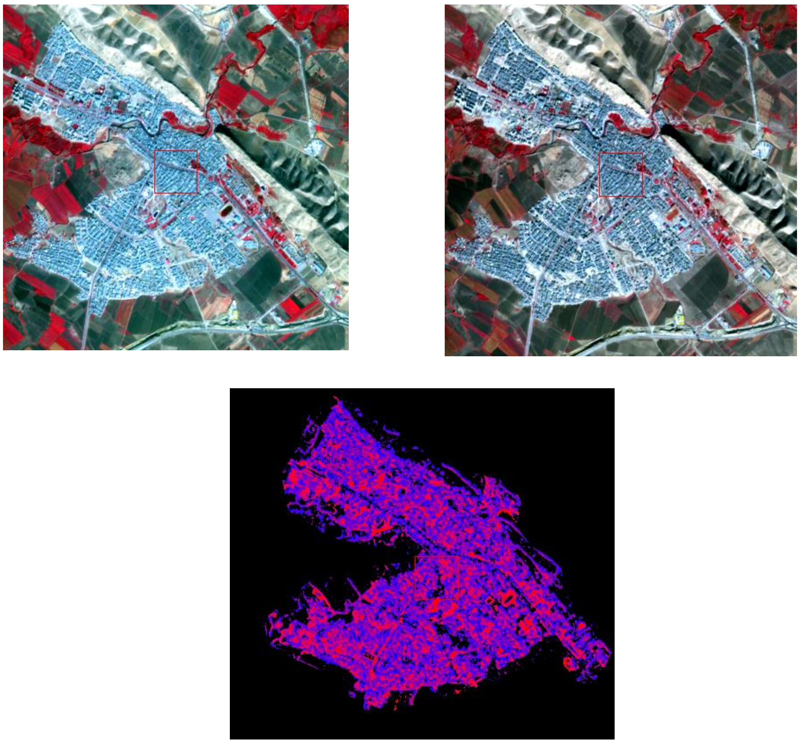

Fig. 3. Pre- and post-event Sentinel-2 images and damage map of the study area

The accuracy of our damage detection approach is assessed using damage map produced by European space agency (ESA). Table 1 depicts the confusion matrix regarding the accuracy of our proposed method. Based on this table, the overall accuracy of our proposed approach is about 70 %.

Table 1. the confusion matrix of our proposed approach

	Undamged	**Damaged**	**Producer acc. (%)**	**User acc. (%)**	**Overall acc. (%)**
Undamaged	14442	18468	68.84	43.85	68.26
Damaged	6527	39355	680.6	85.77	

Conclusion

In this paper, a rapid damage mapping approach is proposed to detect damage areas from Sarpol-e Zahab earthquake. The proposed method is based on change detection and unsupervised. From the perspective of change detection, our proposed approach is robust. To assess the capability of the proposed method, it was applied in Sarpol-e

Zahab earthquake. Using pre- and post-event Sentinel-2 images, the proposed approach can detect damaged areas with an accuracy of 80 %.

Keywords: Rapid damage mapping, Sentinel-2, earthquake, remote sensing, Sarpol-e Zahab.

References

[1]. M. Janalipour and A. Mohammadzadeh, "Building damage detection using object-based image analysis and ANFIS from high-resolution image (Case study: BAM earthquake, Iran)," *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing,* vol. 9, pp. 1937-1945, 2015.

[2]. M. Janalipour and A. Mohammadzadeh, "A fuzzy-ga based decision making system for detecting damaged buildings from high-spatial resolution optical images," *Remote Sensing,* vol. 9, p. 349, 2017.

[3]. M. Janalipour and A. Mohammadzadeh, "Evaluation of effectiveness of three fuzzy systems and three texture extraction methods for building damage detection from post-event LiDAR data," *International journal of digital earth,* vol. 11, pp. 1241-1268, 2018.

[4]. M. JANALIPOUR, A. MOHAMMADZADEH, Z. M. J. VALADAN, and S. AMIRKHANI, "BUILDINGS'DAMAGE DETERMINATION AFTER THE EARTHQUAKE BY USING ANFIS MODEL AND REMOTE SENSING IMAGERY," 2015.

[5]. D. Tiede, S. Lang, P. Füreder, D. Hölbling, C. Hoffmann, and P. Zeil, "Automated damage indication for rapid geospatial reporting," *Photogrammetric Engineering & Remote Sensing,* vol. 77, pp. 933-942, 2011.

Flood Hazards Susceptibility Map and its Occurrence Probability using Shannon Entropy Model (Case Study: Firoozabad River Basin)

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Introduction

Among natural hazards, flood is very important. One of the main ways to reduce the risks of floods is to provide flood sensitivity maps. . Between 1988 and 1997, around 390000 people were killed by natural disasters in the world, 58% were flood victims, 26% were affected by a storm and another 16% by the earthquake. The total livelihoods in these 10 years was about 700 billion $. That is 33, 29, and 28 percent were respectively from storm, earthquake, and flood. In this regard, a worrying trend is the increasing trend of mortality and flood damage in the world in recent decades. Increasing population and assets in flood plains, and the changes in hydrosystems and the destructive effects of human activities have been a major cause of this trend. In this research, Shannon entropy model has been used to provide flood sensitivity maps.

Research and analysis

Firoozabad is a city with an area of 11917 km southwest of Fars province. The city of Firoozabad is located at 28 degrees and 50 minutes north latitude, 52 degrees and 34 minutes east, with an altitude of 1325 meters from sea level. The Firoozabad basin is one of the sub-basins of the Mordan watershed. The Mard watershed with an area of 4,785 and 400 hectares, extending to the territory of three provinces of Fars, Bushehr and Hormozgan. The area of this basin is 3165 meters high from Khorramkouh in southern Zagros to the Persian Gulf coast. For the study of flood, 34 flood waters were first selected in the Firoozabad basin, and then these 34 points were classified into two groups. With 22 points, 65 percent of the points for training and modeling, and 12 points, 35 percent of the locations that were not used in modeling were used for validation. First, a map of the status of the floods was developed. Then, 10 factors, slope, tilt, lithology, land use, NDVI, SPI, TWI, altitudes, rainfall and distances from the river, were selected as flood factors in Firoozabad basin.

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Discussion

Prioritizing the effective factors in the occurrence of flood by Shannon entropy index showed that NDVI layers (2.03), rainfall (2.00), distance from river (1.89), SPI (385.1), altitudes (0.999), gradient with weight (0.932), lithology (0.478), TWI (0.379), and land use (0.280), respectively (0.184) have the highest lowest impact on flood events. NDVI is the most important factor in the occurrence of flood in terms of Shannon entropy. In order to prepare a flood susceptibility map, 10 factors were prepared. After final weight of each factor by Shannon Entropy model and its multiplication in the classes, the weight maps were combined and the final flood sensitivity map was prepared. Then, the final map was classified into 5 classes of very low, moderate, high and very sensitive sensitivity. According to the central part of the basin, the map is more susceptible to flood sensitivity. To provide a distance map from the river, using the multiring buffer command was used in ArcGis software, and classified into five classes. To provide the effective factor of elevation classes, a digital elevation model was used in ArcGis software, and classified into five classes. Two important factors (SPI) and (TWI) are known as important factors in connection with water. TWI is the amount of flow accumulation in each location in the catchment area and flow trend downstream by gravity. To ensure the accuracy and validation of the maps prepared in this study, a regional attribute index or ROC curve was calculated from the area after the field survey. The basis of the results of the ROC curve for the Firoozabad Basin, for predicting the surface area under the curve with 35% of the validation data is 92.42%, and for the success rate with 65% of the education data, is equal to 93.53%. Therefore, Shannon entropy model has acceptable accuracy in preparing a flood susceptibility map in Firoozabad basin.

Conclusion

Shannon entropy model has acceptable accuracy in preparing flood susceptibility map in Firoozabad basin. Entropy is one of the management approaches used to deal with irregularities, instability of turmoil and uncertainties in a system. According to the final map, the sensitivity of the flood around the Firoozabad River is susceptible to a high flood event. Therefore, the construction of residential lands and agricultural lands and gardens around the river should be avoided. According to the results of the study, a natural disaster sensitivity map such as flood is important to manage and plan the future. Preparation of flood susceptibility map and its occurrence probability using Shannon entropy model (case study of Firoozabad river basin) is necessary to prevent financial and financial losses to these sectors.

Keywords: Flood hazards, susceptibility map, probability, Shannon entropy model, Firoozabad river basin.

Assessment and Zoning of Flash Flood Risks based on MFFPI Model (Case Study: Islamabad Basin)

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(Resaved 15 June 2019- Accept 16September 2019)

Introduction

An immediate flood is a rapid flood that is caused by heavy rainfall or sudden release of water over a short period of time while water flowing over the earth (Huang et al., 2013, p. 325). Great floods have the same consequences, hydrogeomorphological effects (Martin et al., 2012, 49), biological effects (Richter et al., 2000, 1469), and socioeconomic effects (Mirz, 2007, 233). This means creating high financial costs and reducing socioeconomic development (Moses et al., 2010, 112). Flash floods are causing severe material damage, human casualties and extreme erosion (Farhan and Ayid, 2017, 718). Although flooding is only heavy rainfall, the hydrological response varies depending on the slope physiognomic features, soil texture, ground cover, rock permeability, and range curvature (Tinco et al., 2018,593). In order to reduce the risk of flash flood, it is necessary to identify and classify areas with high flood hazard potential (Minya, 2013, p. 345). The Islamabad basin is located in the Zagros zone, and the lithologic and geological conditions have caused the geomorphologic features of the Jurassic mountains and the lagging mountains around the syncline plain of Islamabad. This basin is sometimes faced with the risk of flood and river floods due to the severe and short-lived rainfall (W., 1391, 79). Considering the flood history of the Islamabad basin, it is necessary to assess the potential risk of the flash flood. The purpose of this study is to evaluate and map the potential for a flash flood hazard using physiographic parameters.

Materials and methods

The Predicted Flood Potential Model (MFFPI) uses six parameters of physiognomy with specific coefficients to capture the potential flood hazard potential (Table 1). Each of the six parameters, classified according to the impact of the flash flood event, is classified into five classes, and each of these classes has a weight of 1 to 5 according to the role played by the amount of water accumulation. The weight of each parameter in each of the five sub-parameters is multiplied and the final score of each layer is calculated (Tinco et al., 2018,596). In this research, the MFFPI model is implemented in two stages.

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In the first step, each of the six parameters is used in the preparation of a potential risk map for the basin's sudden risk. In the second stage, based on Spearman correlation and linear regression, the effective parameters are selected and based on which the MFFPI model is implemented.

Findings

In the first step, the MFFPI's final potential mapping map shows that areas with very low potential and very low flood peculiarities are consistent with the basin's heights. These areas were not susceptible to water accumulation because of topographic conditions and the possibility of flooding was very low in these areas. Areas with a high potential hazard flash flood is within the reach of the Islamabad plain of the west and the bedrock of the main rivers of the Ravand River, and the topographic conditions of the area are the main cause of the high potential of the sudden flood in these areas. Using Spearman method, the correlation coefficient between six variables was used. The results of this method show that all parameters are correlated and the Sig value is zero. The results of linear regression show that four topographic slope variables, flow accumulation, domain curvature and land use are statistically significant and account for 96.6% of the potential flood index. The two-soil texture and rock permeability variables are not significant. In the second step, the final potential map of the MFFPI model is prepared using four parameters. The survey shows that areas with a low flood hazard potential correspond to the heights of the basin and are not prone to accumulation due to the slope. Areas with a high potential hazard has potential of a sudden flood within the reach of the Islamabad plain and on the main bed of the Ravand River.

Conclusion

The final map of the potential risk of flashflood event from the MFFPI model in the first phase indicates that 45% of the area of the Islamabad sub-basin has a high-risk potential. Also, 13% of the area in the basin has a medium risk potential and 42% of the area is located in a dangerous and very low area. The spatial distribution of hazard potential zones is subject to the topographic conditions of the basin and areas with a potentially hazardous location in mountainous areas that do not contribute to the accumulation and accumulation of water. Areas with a high-risk potential the flash flood in the plain areas of Islamabad and around the Ravand River bed is due to the fact that these areas are prone to accumulation and accumulation due to topographic conditions and the existence of a river. Four variables of topographic slope, flow accumulation, domain curvature, and land use explains 96.6% of the flood potential index and the potential flood event map in the second phase was based on them using the MFFPI model. A final flood potential map survey in the second stage showed that areas with a potential high risk of 34% of the basin area, areas with an

average potential of 17%, and areas with a potential risk of 49% of the area of the Islamic Basin have been allocated. In the map of the potential for flash flood, in the second stage, the spatial distribution of hazard zones follows the topographic conditions and flow accumulation. The removal of soil texture parameters and rock permeability in the second stage reduced the area of high-risk areas and increased the area of low and middle areas. Finally, it can be acknowledged that the results of the MFFPI model at both levels indicate a high risk of flash flood in the area of the west Islamabad, and that the city and all its villages and its surface infrastructure are at risk of flash flood.

Keywords: Flash Flood, MFFPI Model, Zoning, Flood Potential, Islamabad Basin.

References

[1].Negaresh, Hussein, Wisie, Jalil, (1292). Analysis of the effects of rainfall changes in the flood waters of the Ravand catchment area (Islamabad Gharb - Kermanshah Province), Regional Journal of Regional Planning, No. 11, pp. 79-98. [In Persian]

[2].Alhasanat, H. (2014). Flash Flood Assessment for Wadi Mousa City-Jordan. Procedia Economics and Finance, 18, 675-683.

[3].Angillieri, M. Y. E. (2008). Morphometric analysis of Colangüil river basin and flash flood hazard, San Juan, Argentina. Environmental geology, 55(1), 107-111.

[4].Ayala, I,(2002). Geomorphology, natural hazards, vulnerability and prevention of natural disasters in developing countries. Geomorphology 47 (2002) 107–124.

[5].Bapalu, G. V., & Sinha, R. (2005). GIS in flood hazard mapping: A case study of Kosi River Basin, India. GIS Development Weekly, 1(13), 1-3.

[6].BORCAN, M., & RETEGAN, M. (2016). ASSESSMENT OF THE FLOOD OCCURRENCE POTENTIAL IN THE UPPER TELEAJEN RIVER BASIN. Annals of the University of Oradea, Geography Series/Analele Universitatii din Oradea, Seria Geografie, 26(1).

[7].Bukle, P, (2007), Community Based Management: A New Approach to Managing Disasters, Proceeding of ESA Conference, Visions and Divisions, Helsinki, August 28-september 1,pp364-383.

[8].Cao, C., Xu, P., Wang, Y., Chen, J., Zheng, L., & Niu, C. (2016). Flash flood hazard susceptibility mapping using frequency ratio and statistical index methods in coalmine subsidence areas. Sustainability, 8(9), 948.

[9].Carlson, T. N. (2004). Analysis and prediction of surface runoff in an urbanizing watershed using satellite imagery. Journal of the American Water Resources.

[10]. Constantinescu, Ş. (2011). Observaţii asupra indicatorilor morfometrici determinaţi pe baza MNAT.

[11]. Eze BE, Efiong J (2010) Morphometric parameters of the Calabar River basin: implication for hydrologic processes. J Geogr Geol 2:18–26.

[12]. Farhan, Y., & Ayed, A. (2017). Assessment of flash-flood Hazard in arid watersheds of Jordan. Journal of Geographic Information System, 9(06), 717.

[13]. Hong, Y., P. Adhikari, and J.J. Gourley,(2013), Flash flood, in Encyclopedia of Natural Hazards, P.T. Bobrowsky, Editor., Springer: Dordrecht. p. 324-325.
[14]. IF-NET .2005. Flood net brochure.
[15]. Lee, B. J., & Kim, S. (2019). Gridded Flash Flood Risk Index Coupling Statistical Approaches and TOPLATS Land Surface Model for Mountainous Areas. Water, 11(3), 504.
[16]. Leskens, J. G., Brugnach, M., Hoekstra, A. Y., & Schuurmans, W. (2014). Why are decisions in flood disaster management so poorly supported by information from flood models. Environmental modelling & software, 53, 53-61.
[17]. Merz, B., Thieken, A. H., & Gocht, M. (2007). Flood risk mapping at the local scale: concepts and challenges. In Flood risk management in Europe (pp. 231-251). Springer, Dordrecht.
[18]. Minea, G. (2013). Assessment of the flash flood potential of Bâsca River Catchment (Romania) based on physiographic factors. Open Geosciences, 5(3), 344-353.
[19]. Musy, A., & Higy, C. (2010). Hydrology: a science of nature. CRC Press.
[20]. Panizza, M, (2004), ENvironmentalGeomorphology,ENCYCLOPEDIA of GEOMORPHOLOGY, volume 1, Routledgepress, P. 318-320.
[21]. Richter, B. D., & Richter, H. E. (2000). Prescribing flood regimes to sustain riparian ecosystems along meandering rivers. Conservation Biology, 14(5), 1467-1478.
[22]. Ryu, J. H., & Kim, J. (2019). A Study on Climate-Driven Flash Flood Risks in the Boise River Watershed, Idaho. Water, 11(5), 1039.
[23]. Smith, G. (2003). Flash flood potential: Determining the hydrologic response of FFMP basins to heavy rain by analyzing their physiographic characteristics. A white paper available from the NWS Colorado Basin River Forecast Center web site at http://www. cbrfc. noaa. gov/papers/ffp_wpap. pdf.
[24]. Smith, G. E. (2010). Development of a flash flood potential index using physiographic data sets within a geographic information system (Doctoral dissertation, The University of Utah).
[25]. Tincu, R., Lazar, G., & Lazar, I. (2018). Modified flash flood potential index in order to estimate areas with predisposition to water accumulation. Open Geosciences, 10(1), 593-606.
[26]. Veress, M., Németh, I., & Schläffer, R. (2012). The effects of intensive rainfalls (flash floods) on the development on the landforms in the Kőszeg Mountains (Hungary). Open Geosciences, 4(1), 47-66.
[27]. Wicht, M., & Osinska-Skotak, K. (2016). Identifying urban areas prone to flash floods using GIS–preliminary results. Hydrol. Earth Syst. Sci. Discuss. https://doi. org/10.5194/hess-2016-518.

Evaluation of Geomorphosites and Analysis of their Strengths and Weaknesses Using GAM and M-GAM Models (Case Study: Sardasht City)

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Introduction

Geomorphosites are Geomorphological sites the results of both internal and external dynamics over time. It has Scientific, Ecological, Cultural, Aesthetic and Economic values that play an immense role in understanding the Paleo-Geomorphological evolution of local areas. Considering the importance of the topics of Geotourism in the decades and especially in recent years, different countries have developed the national list of Geomorphosites. Accordingly, Geological and Geomorphologic diversity is a point for sustainable regional development in the form of Geologic Tourism and Geotourism. The Geotourism studies provide the basis for creating a management route at the Geomorphosites from beginning to end and ultimately leads to better development and promotion of Geomorphosites. The existence of these studies, focusing on assessing the position of Geomorphosites, especially the management approach, has led to a considerable progress toward the sustainable development.

Methodology

The main methodology of this research is based on Theoretical studies (Theoretical and Library), field studies in the path of recognition of Geomorphosites, as well as questioning with statistical analyzes in a quantitative-qualitative and analytical framework based on the GAM and M-GAM Model. In the research process, topographic maps of 1: 50000, Geological maps of 1: 100,000, along with Google Earth images, have also been used. The GAM method is a Geomorphosites assessment Model that was formally presented by Vujicic and colleagues in 2011. This method is based on Peralong (2005), Perera et al (2007), Zurus (2007) and Reynard et al. (2008) Models. The GAM methodology, including the main value (MV), includes scientific-educational value (VSE), aesthetic value (VSA) and protective value (VPr), each with four sub-criteria. Added value (AV) also includes functional value (VFn) with 6 sub-criteria and also touristic value (VFn) with 9 sub-criteria. The assessment of this method includes the main value with 12 sub-criteria and the

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added value with 15 sub-criteria, which is a total of 27 sub-criteria and formulated as follows:

$$GAM= MV(VSE+ VSA+ VPr)+ AV(VFn+VTr) \quad (1)$$

Finally, based on the results of the evaluation, a matrix consisting of the main and the additional values is created. The two existing values are represented in two axes, X and Y, and are presented as a special chart of the GAM to display the Geomorphosites and their position.

Another Model is M-GAM. This Model is also a Geomorphosites evaluation method based on the GAM methodology. The structural difference and the improvements in it include the views of Tourists in the process of evaluating indicators. Visitors estimate the significance (Im) of each parameter from the 27 sub-criteria in the GAM method. Finally, the general formula for estimation in M-GAM is as follows:

M- GAM= Im(GAM)or Im(MV+AV)

Finally, based on the results of the evaluation, a matrix consisting of the main and the additional values is created And the Geomorphosites are interpreted.

Discussion

This research, aims to study the Geomorphosites analysis with the management approach. Accordingly, the research process involves two parts of the environmental analysis and effective parameters, the identification and selection of Geomorphosites, their quantitative assessment with a systemic view, and finally analysis of their position with the management approach. The study area has a high structural complexity, as a product of the Sanandaj-Sirjan zone activity, the prevailing trends in Azerbaijan as well as the Zagros Thrust. Therefore, the Geological conditions have led to the diversity of the form and process in the study area. Therefore, the above-mentioned conditions are the basis for potential in the Geomorpho- diversity and Geomorphosites regions of the study area. In the phase of its monitoring, fourteen Geosites were identified and selected from the study area. The fourteen Geosites were included (Shalmash waterfall, Razga waterfall, Bitoosh Karstic mass, Sarperdan karstic mass, Kachaka Cave, Homel mountains, Tarkhan mountains, Gravan Spring , Vazne Plain, Biwran region, Mirabad protected forest, Zab river (Kalwe plain), Rassoul Sheet Springs and Vazne river). In the next step, the quantitative evaluation phase was performed based on the opinion of 15 experts. The results of the assessment based on GAM Model showed that the Shalmash, Mirabad, Biwran and Gravan geosites occupy the highest position. The Kachaka cave geomorphosites, which have the lowest and the next rank, are the Sarperdan mass, Bitoosh and Razga waterfall. From the perspective of the GAM diagram, it was also observed that most of the Geomorphosites are located in the Z21, Z22 and Z32 zones. Based on the existing Matrix based on the experts' opinions, the range of obtaining the main value points is 5/5 to 9/75 and the added value is from 4 to 9/25.

Based on the M-GAM Model, the Geomorsites were also evaluated. The results showed that the three Geomorphosites of Shlomash, Gravan, and Biwran had the highest scoring value. The reason was also related to aesthetic values. The results of the Geomorphosite evaluation also determined the importance of the main values, and there is a need to pay more attention to benefit.

Conclusion

The final analysis showed that in high-grade Geomorphosites, scientfic-educational value and aesthetic value were very high but their protective value was low. For instance, in the highest Geomorphosite such as the Shalmash waterfall, the protective value was 2.5, while the Scientific and Aesthetic value was between 3.5 and 3/75. The results of this study showed that in the most of the Geomorphosite the functional value is high, But in lower Geomorphosites, the touristic value is less than the functional value. For example, in the lowest Geomorphosite, such as the Kachaka cave, the tourist rating is 1/25 to 1/5, while the functional rating is 2.75 to 3.

The analysis of the matrix and the special chart of GAM also showed that most of the Geomorphsites are located in Z21, Z22 and Z32 zones. Therefore, it indicates that the main values and related sub-values are higher than the added values which is debatable from a management perspective. Therefore, the study of Geomorphosites with a management approach in the route of sustainable regional development showed that due to the inadequate position of conservation value in Geomorphosites, Geoconservation strategy should be considered in them. The results of this study showed that some Geomorphosites are active and some are inactive, one of the most significant Geoconservation policies is to educate the local community on the path to Geomorphosites participation. Also, the results based on M-GAM showed that the Touristic value has a lower level than the Functional value, Therefore, one of the basic strategies for sustainable development of Sardasht city is the identification and advertising at the weak Geomorphosites, and also branding at the high level of Geomorphosites. Therefore, this process is valuable for the Sardasht city, which is a borderline and deprived area.

Keywords: Geomorphosite, GAM Model, M- GAM Model, Sardasht city.

Reference

[1].Abasnejad, A; Abasnejad, B; (2012), Investigating the Impact of Earth Mineralogy Diversity on the Geodiversity and Biodiversity, First Iranian Geological Heritage Conference, Geological Survey of Iran.

[2].Alexandrowicz Z, Kozlowski S (1999) From selected geosites to geodiversity conservation—Polish example of modern framework. In: Barettino D, Vallejo M, Gallego E (eds) Towards the balanced management and conservation of the geological heritage in the new millenium. Sociedad Geológica de España, Madrid, Spain, pp 40–44

[3].Brilha; J; (2016), Inventory and Quantitive Assessment of Geosites and Geodiversity Sites: a Review, Geoheritage, 8, pp: 119-134.

[4].Comanescu, L; Nedelea, A; Dobre, R; (2011), Evaluation of geomorphosites in Vistea Valley (Fagaras Mountains- Carpathians, Romania), International Journal of the Physical Sciences, 6(5), pp:1161-1168.

[5].Darvishzadeh, A; (2004), Geology of Iran, 3nd Edition, Amir Kabir Press, p:255.

[6].El Hadi; H; Taheri; A; Brilha; J; Madiani; A; Baghdad; B; Zaidi; A; (2015), Geodiversity Examples of Moroco: From Inventory to Regional Geotourism Development; open Journal of Ecology, 5, pp: 409-419.

[7].Garcia- Cortes, A; Rabano,I; Locutura, J; Bellido, F; Fernandez- Gianotti, J; Martin- Serrano, A; Quesada,C; Barnolas, A; Duran, J. J;(2001), First Spanish contribution to the Geosites Project list of the Geological frameworks established by consensus, Episodes, 24(2), pp: 79-92.

[8].Ghanavati, E; Karam, A; Fakhari, S; (2014), Assessment of Geoconservation with emphasis on Geotourism, Quantitive Geomorphological Research, 3(10), pp: 77-89.

[9].Hose; T. A; (1997), Geotourism- selling the earth of Europe, Engineering geology and the environment, Amsterdam.

[10]. Hose; T. A; (2000), European Geotourism- geological interpretation and geoconservation promotion for tourist, Geological geritage: its conservation and management, Madrid.

[11]. Hose; T. A; (2003), Geotourism in England: a two- region case study analysis, Ph.D. thesis, University of Birmingham, Birmingham.

[12]. Khezri, S; (2001), Physical Geography of Moceryan Kurdistan, Naghos Press, p:245.

[13]. Moghimi, E; (2015), Hazards Science, 2nd Edition, University of Tehran press.

[14]. Pereira; P; Pereira; D. I; Alves; M; (2007), Geomorphosite Assessment in Monteshino Natural Park(Portugal), Geogr Helv, 62, pp: 159-168.

[15]. Pontes, H; Massuqueto, L. L; Fernandes, L. A; Carlos, A; Melo, M. S; Moreira, J.S;(2018), Caves Geodiversity Evaluation as an Instrument to the Management of the Campos Gerais National Park, Southern Brazil, Geoheritage, DOI: 1007/s12371-018-0317-09.

[16]. Pralong; J. P; (2005), A method for assessing tourist potential and use of geomorphological sites, Geomorphologie: Relief Processus Environ, 3, pp: 189-196.

[17]. Reynard, E; Coratza, P; (2016), The importance of mountain geomorphosites for environmental education: examples from the Italian Dolomites and the Swiss Alps, Acta Geographia Slovenica, 56(2), pp: 291-303.

[18]. Reynard; E; (2008), Scientific research and tourist promotion of geomorphological heritage, Geographia fisicae dinamica quaternaria, 31(2), Turin.
[19]. Salari, M; (2006), Analysis of hydrogeomorphological charactistics and the estimation of erosion and sediment in Vazneh basin, Master Thesis, Faculty of Geography, university of Tehran, p:144.
[20]. Salari, M; Shahabi, H; Salari, S; (2015), Management (recognition and Prioritize) Geomorphosites using Entropy and Saw methods (Case study: Sardasht city Geomorphosites), Quantitive Geomorphological Research, 4(4), PP: 166-180.
[21]. Sallam, E; Fathy, E; Ruban, D; Ponedelnik, A; Yashalova, N; (2018), Geological heritage diversity in the Faiyum Oasis (Egypt): A comprehensive assessment, Journal of African Earth Sciences, 140, PP: 212-224.
[22]. Salmani, M; Faraji Sabokbar, H. A; Nazemi, M, Orouji, H; Evaluation of the Capabilities and Uses of Geomorphosites (Case Study: Geomorphosites of Tabas County), Human Geography Research, 47(1), pp: 177-192.
[23]. Shayan Yeganeh, A. A; Zangane Asadi, M. A; Amir Ahmadi, A; (2016), 11(34), pp:41-64.
[24]. Tomic, N; (2011), The Potential of Lazar Canyon(Serbia) as a Geotourism Destination: Inventory and Evaluation, Geographica Pannonica, 15(3), pp: 103-112.
[25]. Tomic; N; Bozic; S; (2014), A modified Geosite Assessment Model(M-GAM) and its Application on the Lazar Canyon area(Serbia), Int. J. Environ. Res, 8(4), pp: 1041- 1502.
[26]. Vujicic; M. D; Vasiljevic; D. A; Markovic; S. B; Hose; T.A; Lukic; T; Hadzic; Olga; Janicevic; S; (2011), Prelimentary Geosite Assessment Model(GAM) And Its Application On Frusak Gora Mountain, Potential Geotourism Destenation Of Serbia, Acta geographica Slovenica, 51(2), pp: 361-377.
[27]. Wimbledon; W. A; Benton; M. J; Bevins; R. E; Black; G.P; Bridgland; D.R; Cleal; C.J; Cooper; R.G; May; V. J;(1995), The development of a methodology for the selection of British Geological sites for geoconservation: part 1, Mod Geol, 20,pp:159-202.
[28]. Yazdi, A; (2013), Geodiversity of Iran The factor promoting Geotourism and Sustainable Development, The 2nd National Tourism.
[29]. Yazdi, A; Dabiri, R; (2015), An introduction to Geodiversity as a basis for development of Geotourism, New findings of Applied Geology, 9, 18, pp: 74-82.
[30]. Zouros, N. C; (2007), Geomorphosite Assessment and management in potential areas of Greece, The case of the Lesvos island geomorphosites, Geographica Helvetica, 62, pp: 169-180.