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Spatial Analysis of Rescue and Relief Bases in Alborz Province in order to Reduce Hazards

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Original Article

Abstract

INTRODUCTION: The occurrence of a huge number of road accidents in Iran makes it necessary to pay more attention than before to the rescue and relief sector, the correct locating of road rescue and relief bases and its development and equipment, especially in Alborz province and topological conditions, geographical diversity and its tourism characteristics. Therefore, in this research, in order to reduce the hazards, the spatial analysis of rescue and relief bases in this province was conducted.

METHODS: In this research, in order to optimize the allocation and locating the rescue and relief centers, the intended indicators were extracted from the Red Crescent Society instructions and after preparing the required data, the weight of each index was extracted and optimized in PSO algorithm in MATLAB environment using AHP hierarchical analysis and OWA weighted average. The obtained weights were applied in the corresponding layers and the optimal points were suggested for the development of the rescue and relief network of Alborz province.

FINDINGS: Finally, prioritizing the development of rescue and relief centers in the province was suggested after evaluating the accident-prone state of the province in relation to the existing and proposed centers as well as the development plans of the province

CONCLUSION: The results showed that the use of PSO algorithm can have acceptable results in the field of optimal locating of rescue and relief centers.

Keywords: Alborz; Optimal locating; Particle swarm optimization algorithm; Rescue and Relief bases

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Introduction

Traffic accidents are one of the consequences of safety deficiency; the importance of this issue highlights the necessity to pay attention to the rescue and relief sector and its development and equipment, taking into consideration the correct and optimal locating of the base and the desirable performance in this regard. Based on this, efficient and optimal management of these accidents has a significant effect on controlling and handling and reducing the effects of accidents, and the time to reach the accident site and performing relief activities is very important. Therefore, it is necessary to carry out basic studies to determine the optimal locations for deployment of rescue and relief bases. In this regard, there are problems and inadequacies such as the disproportion of the number of active bases in the country with the number of covered population, the disproportion of the spatial distribution of the bases with the standard of time coverage, the insufficiency of the number of bases compared to the standard, population and under cover area. Locating is one of the spatial analyzes that has a great impact on reducing the costs of various activities.

The occurrence of a large number of road accidents in Iran necessitates paying more attention to the rescue and relief sector, the correct locating of the road rescue and relief centers and their development and equipment. various factors play role in locating of rescue and relief bases,

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which cannot be investigated and analyzed with traditional methods. Alborz province has many road accidents due to its topological conditions, geographical diversity and tourism characteristics. This issue requires serious attention regarding the locating of roadside Rescue and Relief bases in order to provide better services to the injured in high-accident areas. Based on this, the use of geographic information system (GIS) in locating bases is highly efficient due to the possibility of comparing and evaluating different locations and choosing the optimal location according to the intended criteria.

With about 407 kilometers of intercity roads, Alborz province has the least road length in the country, and at the same time, due to the situation of the province in the west, northwest and north highways of the country, it ranks first in intercity traffic in the country. The highest number of deceased due to out-of-town accidents with 58 deceased people per 100 km belongs to Alborz province, which, despite having the most indicators of the smart transportation system and the relative number of highways in the country, has the first place in the number of deaths on the country's roads assigned to itself (1).

The geographical diversity, along with the diversity of incidents that have occurred in Alborz province and the high concentration of population in this province has increased the vulnerability level of this province in natural and man-made disasters. As one of the most important elements of responding to accidents and incidents, especially in suburban environments, the optimal locating of Red Crescent rescue and relief centers plays a very important role in reducing the response time to various incidents and accidents. In Alborz province, according to the special natural and human conditions, it is necessary to develop the network for responding to accidents and accidents in an optimal way, so that by using the minimum cost (resources), an effective response to accidents and accidents can be given. This issue highlights the necessity to pay attention to the locating of rescue and relief centers in the future development plan in the province more than before. In general, the purpose of conducting this research is:

- Knowing the effective indicators in the optimal performance of intercity rescue and relief centers;
- Upgrading and developing the rescue and relief network in Alborz province with minimum cost;
- Optimization of rescue and relief network using PSO algorithm.

It should be noted that the indicators used in this research were extracted based on the instructions issued by the Red Crescent Society (2) in relation to the locating of rescue and relief centers.

Various methods of spatial optimization of response centers in accidents and incidents have been among the interests of researchers. Therefore, Yang et al. (2022) identified and located rescue bases using the clustering planning algorithm and the improved ant colony optimization algorithm (PA-C-IACO). The results showed that the proposed PA-C-IACO has a better solution quality than the existing methods and showed good robustness and feasibility (3).

Alisa (2018) compared fuzzy multi-objective optimization methods, maximum coverage, geographic information system (GIS), genetic algorithm (GA), ant algorithm, tabu search (TS), and simulated annealing (SA). Combining GA with GIS improved the management of large spatial datasets and led to more accurate results based on grid distance instead of straight line distance. Finally, other optimization methods such as ant algorithm, tabu search (TS), simulated annealing (SA) and TCP-S were used to improve the properties of the solution, and assigning weights to the criteria can improve the final results of the studies. All the proposed methods to solve the problem give equal weight to the considered objectives, except the methods that use AHP to determine the weight (4).

Wang et al. (2021) improved the optimization of the initial population generated by the improved method of Clark and Wright and improved the unordered genetic algorithm. The obtained results could help the smart transportation and logistics system in emergency planning (5).

Paez et al. (2021) addressed the problem of finding victims in a search and rescue environment and, considering the time to save people's lives from an accident, proposed a solution using a robotic team that speeds up the process of searching for survivors. The method used was based on DPSO distributed particle swarm optimization in which each particle swarm represents a single robot. The results showed that the algorithm allows the group to avoid obstacles

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and find potential victims (6).

Okkan and Kirdmire (2020) concluded by using a combination of PSO with Lunberg-Marquardt (LM) algorithm; the combined PSO-LM provides the global stability solution as a result of each random experiment in the program for four different flood data. Also, compared to PSO and another hybrid type called mutated PSO, it achieves fast convergence (7).

Bahrami et al. (2019) investigated the activities and places by identifying the specialties and physical and situational conditions of the rescuers. They used the PSO algorithm as a suitable solution for the post-earthquake rescue and relief problem. the implementation of this algorithm improved 2.4% of the results of the allocation of relief forces (8).

Jing and Shao (2022), considered the P center location selection model with genetic algorithm for urban rail transportation emergency service stations. The results showed this model minimizes the number of emergency service stations while meeting the optimal objective function and reducing the construction cost of emergency service stations. This approach has a significant effect on improving system reliability and reducing emergency risks (9).

Xu et al. (2022), using population heat map and path planning algorithm considering the effect of collapsed buildings, a discrete event simulation (DES) model of hospitals, based on matching injured people and their travel time, designed to calculate temporal changes in medical rescue capability. The results showed that the hospital is not able to respond to the demand for rescue and relief in 72 hours after the earthquake (10).

Mahariba et al. (2022), using the shortest travel time (MSSTT) algorithm, proposed determining the route with limited travel time to reach the destination (11). Beikia et al. (2020) in their research designed an integrated relief chain to simultaneously optimize the preparation and response stages of disaster management and provide a location routing model for assessing injured people and distributing aid under conditions of uncertainty. The results showed that reducing the capacity of distribution centers increases the amount of shortage of resources and the capacity of these centers reduces the amount of shortage of resources (12).

Ramli et al. (2019) provided information on the optimal route used by fire rescue. The optimal route according to the location of the fire station using the development of a plug-in in QGIS requires topology, length and target data, which ultimately provides the shortest route. The research result showed the optimal rescue route from the fire station to the residential area in the central business district in Makassar (13).

Chen et al. (2020) identified the influencing factors and presented a capability evaluation system in order to improve the emergency rescue capability of the fire station. In this system, the criteria layer and the sub-criteria layer have five indicators and 25 indicators, respectively. The Fuzzy Comprehensive Evaluation (FCE) method was used to analyze the selection decision problem and the weight of each of the indicators in the system was determined based on the hierarchical analysis method. The results showed that the emergency rescue capability of the fire station is at the general level (14).

Yaoa et al. (2018) presented a bi-objective spatial optimization model and a constraint-based solution method to generate the Pareto frontier, which enables the identification of alternative fire station locating scenarios. The results showed the value of spatial optimization in helping to plan the fire station and deployment of rescue resources (15).

Bay et al. (2015) identified the weight of each factor based on the hierarchical method of influencing factors in road accidents and then based on pairwise comparison of influencing factors and based on the opinions of experts. The priority map of the existing rescue and relief centers and the replacement of the proposed rescue and relief centers were obtained. The results showed that the density of accident-prone points is at the distance between two road rescue and relief stations, which seems to be influenced by factors such as population, culture, road engineering, climate and the culture of local residents. (16).

Rahimipour Sheikhaninejad et al. (2015) evaluated and optimally located stationary and mobile rescue stations in rural areas of Gilan province using the quantitative method (AHP) and expert choice and GIS software. The results showed that the distribution of rescue and relief centers has not been done optimally in rural areas. Therefore, fixed stations were suggested in villages that were in higher risk tolerance conditions and their useful radius was determined

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based on considerations of population density and the quality of main roads. Also, in order to cover the created vacuum, a mobile (temporary) station was proposed in some places (17).

Ebrahimi et al. (2016) concluded by using multi-criteria decision-making techniques and spatial analysis (GIS), according to the evaluations, crisis management support bases in 18 districts of Tehran have a random and non-principled distribution pattern and in terms of location, it has not been established in suitable spatial areas and the location for establishing bases has been chosen without considering its special needs (18). Miri et al. (2018) investigated the optimal locating of rescue and relief centers in the possible Nahavand earthquake and conducted their studies using the geographic information system and Fuzzy-HP (FAHP). The results showed that suitable places for these centers are scattered throughout the plain, which is considered a good potential for crisis management in this city (19).

Bahrami et al. (2018) proposed a solution for the optimal management of rescue and relief teams in earthquakes using spatial information system and particle swarm algorithm (PSO) and hypothetical earthquake simulation. In this method, using the particle swarm algorithm in a spatial information system, the rescuers were assigned to rescue and relief activities that in less time do more rescue and be more efficient than the experimental and traditional mode. The results of the implementation of the proposed algorithm showed an improvement of about two times the allocation made (20). Kaveh and Mesgari (2018) compared and evaluated the performance of genetic algorithm and hybrid particle swarm optimization algorithm to determine the optimal location of hospital centers and allocate population points to them. The results showed that the combination particle swarm optimization algorithm has a better performance than the genetic algorithm (21). Kharghani et al. (2021) weighted the layers of information using the hierarchical AHP process. Then, using Genetic Algorithm (GA) and Particle Swarming Algorithm (PSO) and with the help of distance criteria, they suggested the optimal point for building a fire station. The performance results of the algorithm showed that PSO reaches the optimal answer in less time than Ga (22).

Karami et al. (2014) investigated the locating of crisis management support bases in Baneh city using hierarchical analysis method and Expert Choice and Arc GIS software. The results showed that natural criteria have less weight than human criteria in locating crisis management support bases. The sub-criteria of proximity to medical centers also had the highest weight and vegetation and the direction of the slope had the lowest weight. In terms of locating, the largest area of Baneh city is not suitable for the establishment of crisis management support bases, and the most suitable place is the middle areas of the city (23).

Ebrahimi (2019) performed modeling using random forest algorithm in order to determine the priority of the factors affecting the occurrence of floods, and finally the flood risk zoning map was divided into four zones: very dangerous, dangerous, medium risk and low risk was prepared. The results showed that in all sub-basins, rainfall is the most important factor in the occurrence of floods in the region, and more than half of the region is located in the very dangerous and dangerous zone (1).

Ejtemaei et al. (2021) investigated the optimal locating of rescue and relief bases in case of occurrence of an earthquake in the central and Chah Varz of Lamard city. They prepare the distance map of the information layers, classify and value the inner layers and finally weight and overlap the layers and prioritize different points to create rescue bases in case of occurrence of an earthquake. The results showed that in the central and Chah Varz of Lamard city, it is more appropriate to consider four levels of management in order to provide timely and more appropriate relief in all places when an earthquake occurs (24).

In domestic and foreign researches, different and diverse methods have been proposed for the optimal allocation of sites for locating rescue centers or similar applications. It is worth mentioning that due to the different structure of crisis management in different countries and the different functioning of incident response centers in Iran, especially in suburban areas, international examples related to spatial optimization of emergency response centers, according to the description of the duties and services provided in the rescue centers of the country, cannot be objectively used and reviewed. For this reason, only the methods used in the optimization of emergency centers have been evaluated in this

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research. In general, it seems that the use of innovative algorithms has been able to provide favorable results for the optimal allocation of rescue centers.

In this research, in order to achieve the main goal of the research, which is to identify suitable areas for the development of rescue centers, the multi-criteria decision-making method and particle swarm optimization algorithm will be used. Also, due to the multitude of indicators introduced in the field of locating rescue and relief centers in different sources, in this research, the standards presented in the current instructions of the rescue and relief organization have been used as the administrator of issuing permits for the establishment and operation of these centers in such a way that the binding indicators in these guidelines are defined as spatial relationships that can be analyzed and used in this research.

Methods

This research is an applied research and the research method used in this descriptive and analytical study includes the review of documents, laws and regulations and statistical analysis methods (spatial statistics) with the aim of identifying and analyzing the location of rescue and relief bases in Alborz province. It was used to reduce hazards. Therefore, in order to achieve the goal, the particle swarm optimization (PSO) method has been used. Optimization algorithms are algorithms that, according to the defined mathematical and statistical models, seek to identify the best situations from communication and the system of actions or objects in such a way that it can find the most suitable situation with the minimum amount of optimization that is defined.

In this research, in order to find the objective function of research or optimization of rescue centers in the defined space of Alborz province, PSO algorithm was used in MATLAB environment. The method of obtaining the optimization criteria and also how to weight them with the OWA method and how to implement it in the MATLAB algorithm is mentioned in the research steps section.

The scope of the research

Alborz province, with an area of 5121.694 square kilometers, as the smallest province of Iran, is located in the geographical range of 50 degrees 10 minutes to 51 degrees 30 minutes' east longitude and 35 degrees 28 minutes to 36 degrees 30 minutes north latitude, in the south of central Alborz highlands. Due to its very strategic location, it is considered as the crossroads of the west and north of the country, which is the connecting point of the transit route of 17 populous provinces of the country. Alborz province is adjacent to Mazandaran province in the north, Qazvin province in the west, Tehran province in the east, and Markazi province in the south. Karaj city is the oldest city in this province. Alborz province has 17 cities, the most populated city is Karaj with 1,592,492 people and the least populated city is Asara with 1,339 people (25). Figure 1 shows the location of the cities of this province.

In this research, in order to optimize the performance of rescue and relief centers of the Red Crescent Society in order to respond effectively to incidents and accidents in Alborz province, first of all, the indicators for optimizing the locating of rescue and relief centers were extracted according to the inherent and legal duties of the Red Crescent Society. Then, the required and the desirability map are implemented to extract the optimal weights of each of the indicators using the PSO optimization model in MATLAB software, and after extracting the weights, they are applied to the prepared information layers. Figure 2 shows the distribution of rescue and relief bases in Alborz province.

The high population density in this province has led to an increase in the density of road accidents, especially on Chalus, Eshtehard and Tehran-Qazvin roads. The distribution of population and settlements and demographic characteristics of Alborz province shows in Figure 3; also Figure 4 shows the distribution of different incidents (2016-2021) in Alborz province, which includes incidents related to mountains, road accidents, debris fall, flood and inundation, snow and blizzard, landslide and earthquake. In the northern half of the province, due to the mountainous conditions and nature tourism, the density of accidents is higher, the fall of debris and landslides are more than other provinces, especially on the Chalus road, and accidents related to snow and blizzards also increase in the winter season.

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Figure 1. Geographical location of Alborz province (source: author)

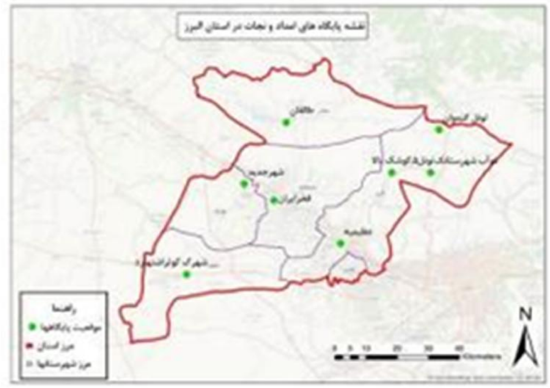
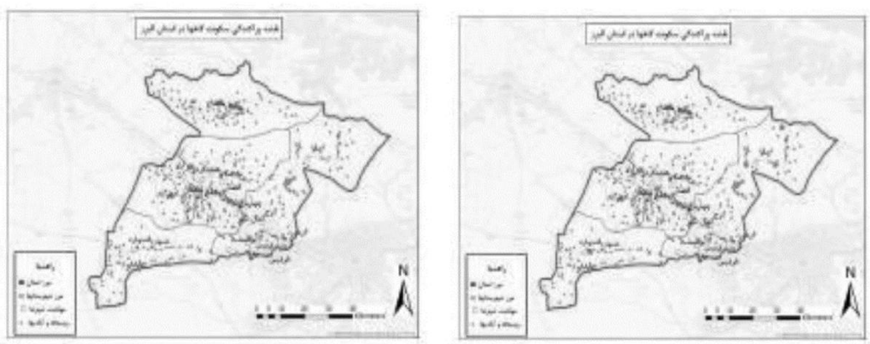


Figure 2. The map of distribution of Alborz rescue and relief bases (source: rescue and relief organization)



Urban and rural settlements The location of relief and rescue bases

Figure3. Population and settlements distribution map (demographic characteristics)

Considering the objectives of this research, the optimization of rescue and relief network is done in order to cover the main transportation route of the country as much as possible in compliance with the executive rules and criteria for the coverage of rescue and relief services in the country. also, in order to develop the country's rescue and relief network, spatial criteria of extraction, weighting and optimal areas are suggested. finally, the effectiveness of the proposed model in improving the coverage of rescue services in the main areas will be measured.

The criteria used in this research are from the study of upstream documents (instructions of Red Crescent rescue and relief bases, executive instructions of the country's crisis management law), interviews with rescue and relief experts, and review of internal reference books and sources and the National Fire Brigade Association of America (NFPA) is collected. Effective indicators in the optimal performance of intercity rescue and relief centers, including distance from population centers, distance from existing centers and bases, distance from existing emergency bases, distance from connecting routes (the closer they are to the main connecting routes, the better) and the distance from the urban areas (the farther the rescue and relief bases are from the urban areas, the better). Based on this, after applying the mentioned indicators, the map of the desirability layer is prepared.

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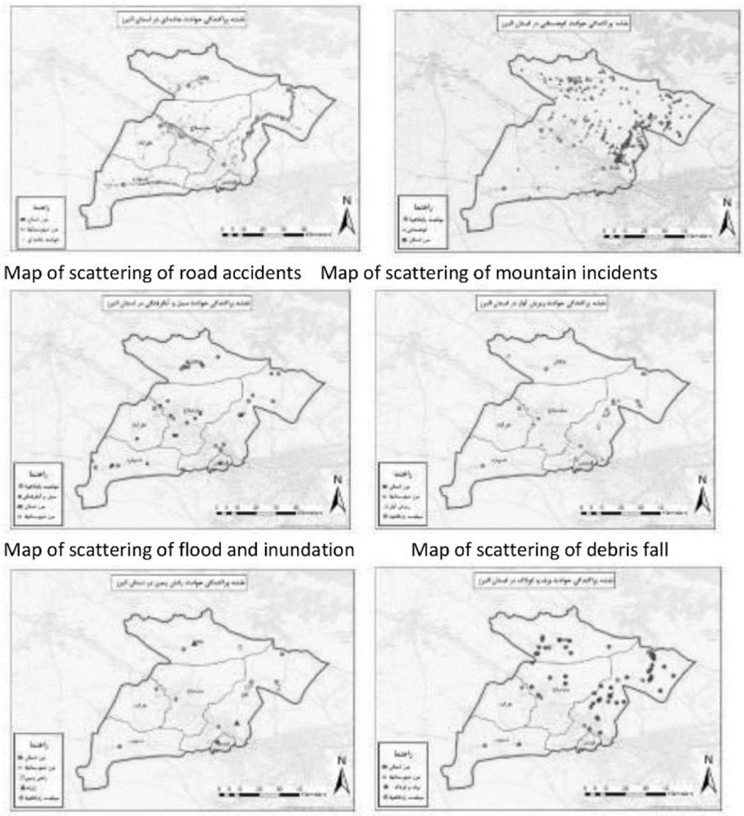

Map of scattering of road accidents   Map of scattering of mountain incidents

Map of scattering of flood and inundation   Map of scattering of debris fall

Map of scattering of landslide and earthquake   Map of scattering of snow and blizzard events

Figure 4. Map of scattering of different incidents

Table 1. Guidelines for rescue and relief centers with the approach of responding to accidents and incidents in Alborz province

Type	Row	Title	Explanation
Limitation	1	30 kilometers distance from the existing bases	With the aim of reducing the overlapping of the functional radius of the bases
Limitation	2	Locating outside the city limits	Due to the lack of legal duties of the Red Crescent community in urban areas (except for natural disasters or the assistance of the responsible authorities)
Factor	3	Proximity to main roads	Facilitating access to the center and covering traffic accidents
Factor	4	Proximity to intercity emergency centers	Playing a role as a person responsible for rescue and evacuation in intercity incidents
Factor	5	Proximity to rural population centers	Maximum coverage of rural areas and access to services available in the village, including water, electricity and other infrastructures required for the operation of the centers.

Ordered Weighted Averaging (OWA) process

According to the guidance nature of the data provided in the guidelines (limitations and factors), the ordered weighted averaging method was used to identify the weighted importance of the extracted indicators. In the first step, by using the AHP method and two-by-two comparison between the intended factors, the weight value of each was extracted, and in the IDRISI software, by defining the limits and factors, the final weight for each of the indicators was extracted and a zoning map was obtained.

Then, in order to estimate the optimal areas, 50 samples were extracted from the results and weights assigned in the OWA method scattered on the surface of the studied area and used for optimization in the PSO algorithm.

In this environment, the final answer is

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influenced by the level of risk-taking and risk-aversion of the decision-maker. The ordered weighted averaging method is introduced as one of the decision-making methods that has the ability to consider the priorities and subjective evaluation of the decision-maker. The process of making the final decision in this method is based on risk aversion and risk taking of the decision maker. In a decision-making issue, risk-taking people emphasize the good properties and risk-averse people emphasize the bad properties of an option and make it the criterion for their choice (26-27-28).

Particle Swarm Optimization Algorithm (PSO)

In this algorithm, first a set of initial solutions is generated and each particle is assumed as a possible solution. Then, in order to find the optimal answer in the space of possible answers, the search for the answer is done by timing the generations. Each particle is defined in a multidimensional way with two values of position and velocity, and at each stage of the particle's movement, with two indices of velocity and position, the best responses are determined for all particles in terms of competence. In better words, the optimum obtained in each step is called pbest and at the end of all steps, gbest, and all the particles based on the obtained pbest and gbest, update their location until the global optimal solution is obtained. The three stages of speed synchronization, position synchronization and objective function calculation continue until the maximum repetition is reached. In this research, according to the executive requirements presented in the instructions for the development of rescue and relief bases in the country, the required indicators were extracted and by using the method of Ordered Weighted Averaging and the method of particle swarm optimization, the areas with the ability to develop the network of rescue and relief has been identified in Alborz province.

Findings

In this research, in order to optimize the location of rescue and relief centers in Alborz province, the proposed criteria and requirements included in the guidelines for the creation of rescue centers announced by the Rescue and Relief Organization (2019) as a guide for the creation and development of rescue and relief bases was investigated. According to the guidance and executive requirements provided in this instruction for the creation and development of the country's rescue and relief network, a number of limitations and a number of environmental features have been proposed, which in total can be extracted as two limitations and three factors for locating. The limitations and factors mentioned in the guidelines for the creation of rescue and relief bases has shown with the approach of responding to accidents and incidents in Alborz province in Table 1.

Data preparation

At this stage, in order to extract the required data in the optimization process, the required layers are prepared in the ARCGIS software according to the type of data, either limitation or factor. The urban area data is classified as a binary layer including the urban area with zero location value and the non-urban areas with one location value (Figure 5). The limitation caused by the functional range of the existing centers was analyzed by using the standard provided in the instructions using the network analysis method in the ARCGIS software, and the functional range of the existing centers up to a radius of 30 km on the communication network of the province was extracted and the spatial value Zero was assigned to it. The areas outside the functional radius of the existing bases received a location value of one (Figure 6).

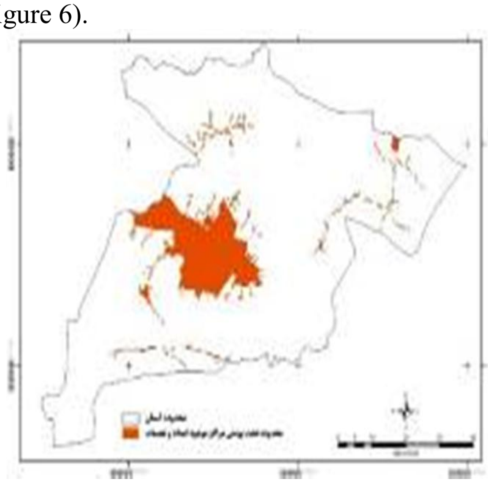

Figure 5. The functional range existing rescue & relief centers of Alborz province

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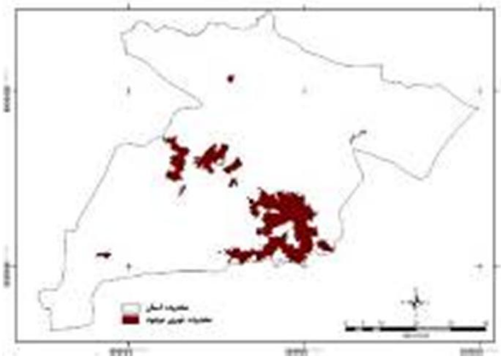

Figure 6. Urban area in Alborz province

The data related to the distance from the rural points, emergency centers and connecting routes were extracted from the existing roads as Euclidean distance as shown in (Figures 7, 8 & 9).

In the next step, the data related to the distance was prepared as a fuzzy layer and the spatial value between zero and one was considered for the farthest and closest distance respectively. The information layers prepared in the next step will be used to determine the effectiveness of each in the location allocation of relief and rescue centers.

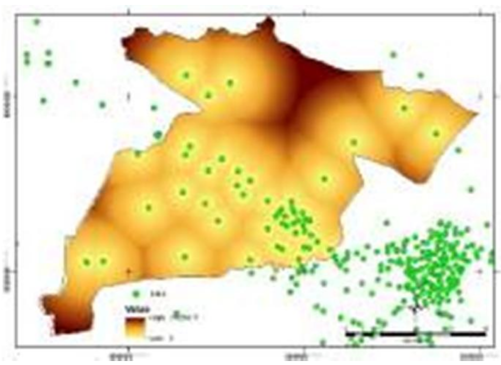

Figure 7. Distance from emergency centers

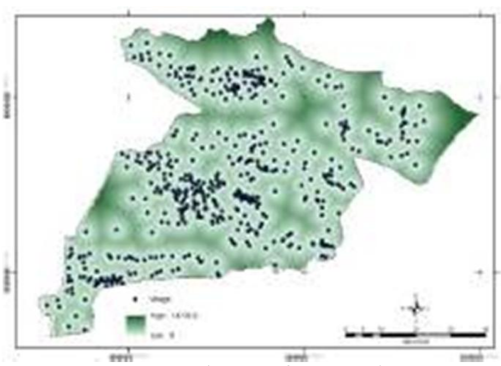

Figure 8. Distance from rural areas

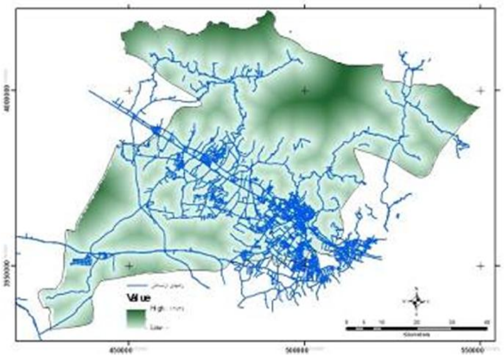

Figure 9. Distance from communication ways

Preparing a utility map

According to the guidance nature of the data provided in the guidelines (limitations and factors), the ordered weighted averaging method was used to identify the weighted importance of the extracted indicators. In the first step, by using the AHP method and two-by-two comparison between the intended factors, the weight value of each was extracted, and in the IDRISI software, by defining the limitations and factors, the final weight for each of the indicators was extracted and a zoning map was obtained. The utility was extracted. The ordered weighted averaging method uses two sets of weights. The first set of weights is general or global weights that show the relative importance of factors. Here, the AHP method was used to extract the weights and determine the relative importance of the factors.

Table 2 shows the relative importance and weights related to the intended factors. According to the table, the most important factors in order are the connecting routes between settlements and emergency centers. Also, the compatibility rate for the comparative matrix of these factors is equal to 0.02.

Table 2. Calculation of weight and compatibility rate of research factors using AHP method

Row	Factor	Weight	Compatibility rate
1	Distance from the road	0/7222	0/2
2	Distance from villages	0/20498	
3	Distance from emergency centers	0/0727	

In the IDRISI software, the extracted general weights and local weights extracted were applied in information layers and limitation layers were used to prepare the utility layer. As a result, a raster layer was obtained as the final output by applying the defined limitations and the weight of

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the factors (Figure 10).

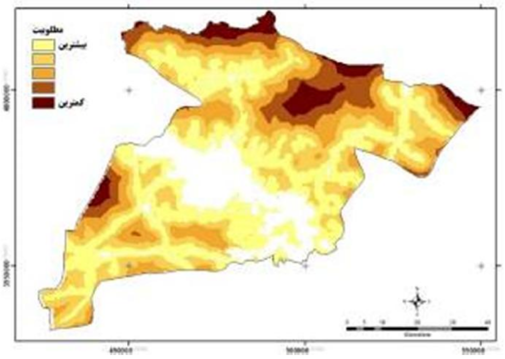

Figure 10. Spatial desirability map by applying the OWA method

Estimation of optimal areas

A number of 50 samples were extracted from the results and weights assigned in the OWA method in a scattered manner on the level of the studied area and used for optimization in the PSO algorithm. According to the sample points extracted in MATLAB software and using the PSO algorithm, the optimal weights were calculated considering 100 repetitions (Figure ١١).

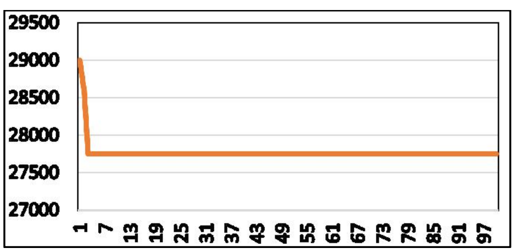

Figure 11. The results of the PSO algorithm implementation in 100 repetitions

The results of the algorithm show the optimal convergence of the input data in 100 iterations. The input parameters in the PSO algorithm are also shown in Table 3.

Table 3. Input parameters in PSO algorithm

Number of Population (NoP) = 100;
Number of Iteration (NoI) = 100;
Inertia Weight (IW) = 2;
Inertia Weight Reduction Factor (IWRF) = 0.99;
Personal Best Learning Coefficients (PBLC) = 0.2;
Global Best Learning Coefficients (GBLC) = 0.2;
Lower Bound of Particle (LBoP) = 0.05;
Upper Bound of Particle (UBoP) = 0.8;

At this stage of the research, the optimal function was defined according to the information layers used, which will be according to the following statement:

$$F = (\min w_1 * road) + (\min w_2 * village) + (\min w_3 * ems)$$

In this regard, they are: cell number (i), weights for each layer ($w_{1,2,3}$), road layer, rural areas layer (village), emergency centers layer (Ems). The result of running the algorithm and applying the optimal weights obtained at this stage were applied to the prepared fuzzy layers and 10 optimal points suggested for the development of the rescue and relief network were obtained.

The distribution of the proposed points is shown in Figure 12. In addition, Figures 13 & 14 show the location of the proposed centers to the existing centers and the location of the proposed centers to the existing road network.

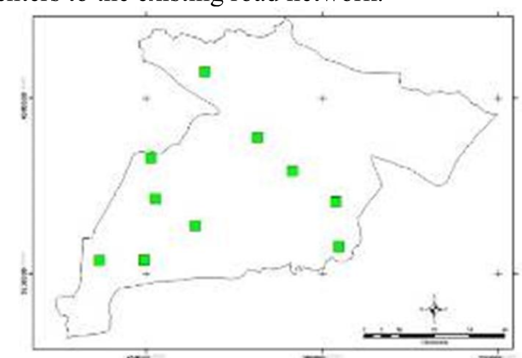

Figure 12. The result of the optimal allocation of rescue and relief centers using the PSO algorithm

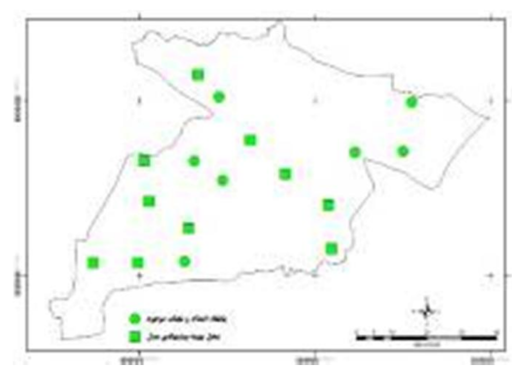

Figure 13. Location of optimal centers proposed to existing centers

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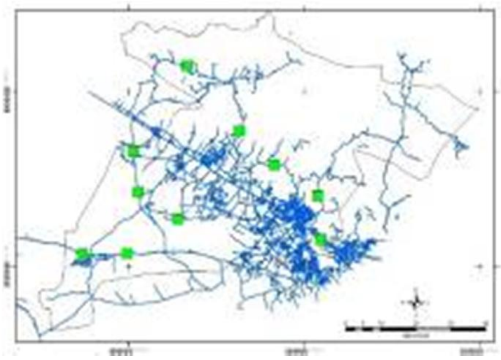

Figure 14. The location of the proposed optimal centers to the existing road network

Presentation of the development program of rescue and relief centers

The overlap of the location of the existing centers with the distribution of accidents in the last 5 years in Alborz province based on the information recorded in the RCS Disaster Management System (DMIS) shows in Figures 15 and 16. Also, the functional radius of the existing centers has a relatively good dispersion compared to hot points (Figure 17).

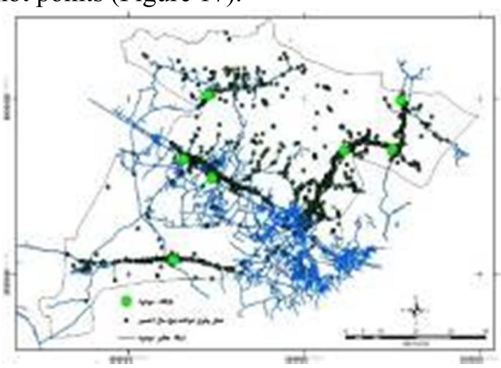

Figure 15. Overlap of existing centers with the distribution of incidents in the last 5 years in Alborz province

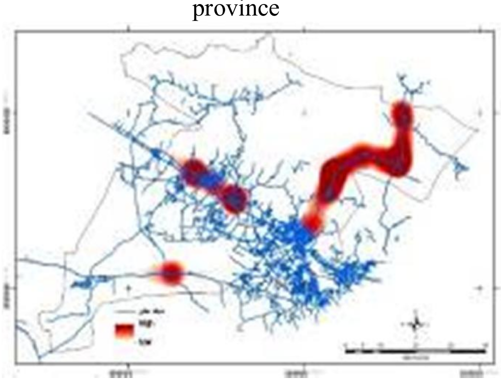

Figure 16. Estimation of the rate of accident in Alborz province using Density Kernel

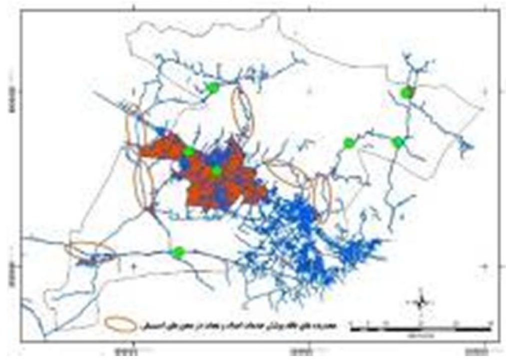

Figure 17. Effective radius of existing centers compared to accident-prone areas

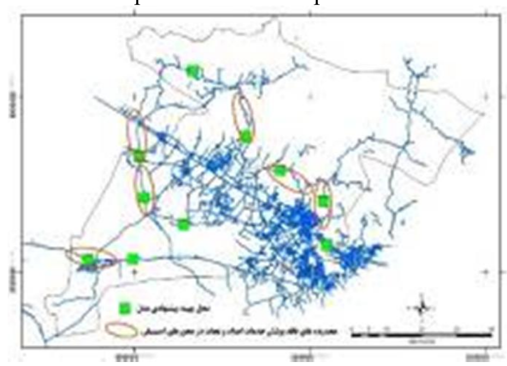

Figure18. Alborz province rescue and relief network development plan using PSO algorithm

However, in some areas, the lack of coverage of rescue services is observed in areas with high dispersion of accidents. On the other hand, the development of the connecting roads of the province (the inauguration of the Al-Ghadir highway and the completion of the Karaj-Taleqan axis) and also the changing of the role of some areas in the province (Eshtehard industrial town and the tourist areas in the north of Karaj city), the need for foresight in the development of the rescue and relief network of Alborz province is highlighted.

Considering the above and also the results obtained from the PSO algorithm, it is possible to propose the development plan of the rescue network of Alborz province according to Figure 18. Considering the results obtained and the future network development plan, it is necessary to provide the necessary prioritization for the step-by-step development of rescue centers in Alborz province. The proposed points based on the instructions for establishing rescue and relief bases have the minimum conditions necessary for establishing the base, and they will also be located in an optimal state.

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Discussion and Conclusion

In this research, based on the instructions for the establishment of the rescue and relief center of the Rescue and Relief Organization, the indicators used in the optimal location allocation of the rescue centers were extracted, and a method of optimizing the allocation and locating of the rescue centers based on the PSO algorithm was presented in Alborz province. Also, the approach of modeling the executive requirements presented in this recipe, in order to increase the precision and accuracy of locating new bases, has been considered. For the purpose of modeling, the intended indicators are extracted from the above-mentioned instructions and after preparing the required data, using AHP and OWA methods, the weight of each of the indicators is extracted and optimized in the MATLAB environment using the PSO algorithm.

The obtained weights were applied in the corresponding layers and the optimal points were proposed for the development of the rescue and relief network of Alborz province. Then, in order to prioritize and select the best points among the proposed points, the accident-prone situation of the province was evaluated in relation to the existing and proposed centers, as well as the development plans of the province. In the end, the suggestion of prioritizing the development of rescue centers in the province was presented.

Using the proposed model in this research, 10 optimal bases were proposed for the development of the rescue network in Alborz province. These proposed places, in addition to strictly complying with executive instructions, have been optimally extracted in terms of spatial location in relation to other environmental and human elements that are effective in the rescue operation. Based on the investigation of the performance of Rescue and Relief bases with a standard functional radius of 15 km for each base, the optimal coverage of the main connecting network of Alborz province has been improved from 70 to 100 percent.

Therefore, since increasing the coverage of rescue services can be considered as one of the important elements in reducing the effect of hazards, the results of this research can increase resilience and reduce casualties at the province level especially in road accidents will be beneficial. Also, the results obtained from this research showed; the use of PSO algorithm can have acceptable results in the field of optimal locating of rescue centers.

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None

Conflict of Interests

Authors have no conflict of interests.

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