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Location of fire stations using AHP model and fuzzy method (Case study: Isfahan City)

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Abstract

Introduction: Fire stations, as places for the establishment and waiting of fire and rescue vehicles, are among the most important and vital service centers in cities, which play an important role in ensuring the safety and comfort of citizens and the development of cities. Therefore, locating fire stations and determining the number of stations in order to properly cover the city and provide services to citizens are vital and necessary measures in this field. The traditional location of these stations has mostly been subject to land ownership and management preferences and such things; Among the disadvantages of examining them in the traditional format, we can point out the inability to use all the effective parameters at the same time and being time-consuming. In this research, using GIS and information integration, correct and scientific location of fire stations has been tried.

Methodology: The current research method is analytical-descriptive-survey in terms of information analysis. Library and descriptive methods have been used to collect information. In this research, 6 main criteria have been introduced as the criteria for introducing land prone areas for the establishment of fire stations, which include: Access, density, size, type of land use, compatible neighbors and incompatible neighbors. In the proposed model of this research, it was assumed that if a piece of land is closer to communication ways, their access to other areas is greater and they are more important for allocation to fire stations. Population density is also considered based on the number of people settled in each urban unit (in terms of number per square meter in an urban block) and entered into the mentioned model as one of the main criteria in locating. The size of the land is one of the important conditions for assigning it to fire stations. Normally, areas with an average size of 1000 to 3000 square meters are considered as high priority areas as suitable places for establishing fire stations. The compatibility and incompatibility criteria are considered based on the potential of causing danger/accident (life and financial) and traffic generating uses, respectively. Finally, the type of land use (sixth criterion) was entered into the mentioned model as a factor that indicates the limitation or non-limitation of land for changing its use to fire stations. In this research, Vicor and Electra methods have been used to select the best location for fire stations in Isfahan city.

Results and discussion: In this research, first, all the required information is included in an integrated database with the same coordinate system, then the identified criteria and sub-criteria are weighted using the AHP process. In order to weight and determine priorities in this research, the criteria identified in the previous step were included in binary form in the form of comparison matrices. Then, referring to expert opinions and a basis prepared from numbers 1 to 9, a descriptive (qualitative) comparison of each pair of criteria involved in

decision making was done. Based on that, the greater the difference between the two criteria (or their priority over each other), the closer the assigned rank will be to the number 9. Finally, by converting the qualitative scale to a quantitative scale, the priority or rank of all criteria was determined. Also, the inconsistency coefficient was used as a factor to estimate the accuracy of pairwise comparisons made by experts' opinions. The obtained values of the inconsistency coefficient for all criteria and sub-criteria in each class were less than 83%, which shows the correctness of the comparisons made in this research. In the field of standardization of maps, different range of fuzzy membership functions based on experts' opinions were used. In the field of selecting fuzzy functions for neighborhood effects (both compatible neighbors and incompatible neighbors), a ranking function was used. However, a kernel function was used to generalize the fuzzy coefficients assigned to it to the neighboring users (and not the users themselves). In this way, the number of each function was assigned to the buffer range of the kernel function, instead of being assigned to the intended user, and then by divorcing the buffers with the main land use maps, the desired number was transferred from the buffer to the neighbor. The side areas were allocated up to a radius of 1000 meters. Finally, by preparing standardized maps for each sub-criterion and multiplying them by their respective weights, basic maps were prepared for carrying out the weighted linear combination method and the final output was prepared based on it.

Conclusion: In this research, by using multi-criteria decision analysis techniques in combination with GIS, the location of fire stations in the city of Isfahan has been addressed. To achieve this purpose, by referring to expert opinions and reviewing available resources in this field, a set of 6 main criteria and also sub-criteria related to it, which have a high potential in identifying the areas of fire stations, are identified, and were collected in an integrated manner in a location-oriented database. The use of fuzzy membership functions in the standardization of criteria was one of the other parameters influencing the identification of areas prone to the establishment of fire stations in this research. One of the remarkable results of the research is that areas with worn-out fabric are not given the first priority for creating fire stations. This issue shows that first of all, the necessary grounds for the renovation of these spaces should be made. In fact, instead of expanding the crisis management and firefighting centers in the danger areas, it is better to reduce the danger and risks in the region first.

Keywords: firefighting, Geographical information system (GIS), Hierarchical analysis process (AHP), fuzzy logic, Isfahan.

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