

CASE STUDY

The role of optimal site selection of fire stations in urban safety

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ABSTRACT

Constructing new urban facilities requires precise study of the proper sitting in different parts of a city. The first point for the accurate allocation of urban facilities, is to select the optimal site regarding different conditions and it matters when it comes to important factors such as saving lives and safety of the people. Therefore, the optimal site selection of fire stations is essential because of the importance of the people who are in danger of fire and hazards. This research is applied in terms of purpose and in terms of method, is descriptive and in terms of data collection is a survey research. For this purpose, using the Analytic hierarchy process analysis in GIS, the results were analyzed by questionnaire. Using the overlapping method, the weighted criteria were combined and the optimal sites for the constructing of fire stations are specified. Results determined areas that have a higher priority and better conditions for the constructing of fire stations. The areas which have the most suitable conditions because of their proximity to the road, residential areas, the existence of health centers, as well as commercial centers, along with the existence of worn out structures, were in the first priority for the construction of new stations. However, other parts of the district are well-suited for construction of new stations that are compatible and in fact confirm the current situation and the status.

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INTRODUCTION

With the rapid growth of population and urbanization in the last century and the need for extensive construction, the number of urban planners who have devoted to urban development and new cities has increased dramatically. The complexity of urban relations and the insufficient familiarity with the rapidly evolving social structure made the prediction of urban events in urban spaces at least extremely difficult so that many artistic predictions were not realized in the design of modern cities (Hall, 2014; Abbaszadegan et al., 2011). Thus, metropolitan construction failed to define a suitable framework

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for subsystems, and subsystems failed to make good connections with the system and became isolated over time and became underdeveloped areas in the process of urban development (Pendall et al., 2010). The existence of urban areas is generally related to the provision of services to residents within the legal and privacy boundaries of cities. Emergency facilities due to their activities are more important in relation to other urban services (Coutinho-Rodrigues, et al., 2012). Firefighting stations are important and vital service centers in cities as places for firefighting vehicles, which play an important role in ensuring the safety and comfort of citizens and the development of cities (Bloomberg, 2003). Therefore, site selection

of fire stations and determining the number of stations for proper coverage of the city and serving the citizens with regard to the characteristics and features of the city and the available financial and logistical capacity and anticipating the development of future facilities are vital measures in this regard (Yang *et al.*, 2007; Waseem *et al.*, 2011; Aktaş *et al.*, 2013). Therefore, the use of information technology, especially geographic information systems, is essential for the analysis of large amounts of data. In fact, the sites that considered to be the outlet should be as responsive as possible to future changes of the dynamic urban system and with the sufficient flexibility to direct city safety services (Jin *et al.*, 2014). Also, the growth, development, and distribution of urban land use have not kept pace with this population growth (Burgess, 2008). In this research, using geographic information system (GIS) and the integration of information, accurate and scientific sitting of fire stations in District 12 of Tehran has been done. Due to the importance of saving human lives in fire extinguishing, many studies have been carried out in developed countries on the selection of suitable sites for fire stations. Initial researches in this regard were based on the site of the stations, which depend on the level of coverage provision of services by each of them. The main purpose of establishing fire stations is to provide part of the city's safety in line with their predefined goals. Achieving this goal requires a systematic and integrated micro view of the urban elements and directing the macro view of the city structure, which this largely achieved through the use of geographic information systems.

Importance of the subject of research

Constructing new urban facilities requires precise study of the proper sitting in different parts of a city. The first point for the accurate allocation of urban facilities, is to select the optimal site with regard to different conditions and it matters when it comes to important factors such as saving lives. Therefore, the optimal site selection for fire stations is essential because of the importance of the people who are in danger of fire. The mere attention to the construction and establishment of the fire stations and less attention to the surrounding land uses and other important factors in their site selection reduces the efficiency of the station in terms of timely relief (Gill, 2005). In addition to the mentioned issues in

relation to the shortage of fire stations, inaccurate site selection and lack of coordination with urban texture and landscape are common issues of many cities in Iran (Shakibamanesh, 2015). In large cities such as Tehran, which are faced with inconsistencies and problems of urban development, optimizing the determination of the distribution of land uses will pave the way for a balanced and harmonious urban development and in the light of maintaining social justice in the future. The questions of this research are based on the importance and necessity are as follow:

- What is the status of the district regarding the number of established fire station?
- What factors should be considered in the site selection for new fire stations?
- What are the factors affecting the site selection of the new fire stations in the area?

Research Background

Adeli *et al.*, (2007) conducted a research on the site selection in the city of Gorgan fire stations using geographic information systems. The main objective was to determine the best sites for the establishment of fire stations in Gorgan or to spatial displacement of some of them (if necessary). For this purpose, first, and after defining the conceptual model, the effective criteria for site selection of the fire stations are identified and the information related to each of them prepared. Rastehgari Yazdi *et al.*, (2011) conducted a study in the city of Qom. The city of Qom is a densely populated, facing shortages in terms of number and distribution of service units including fire stations. With the use of descriptive-analytical and network analysis method in ArcGIS, spatial distribution, sites of the existing fire stations and their operational radius have been analyzed. The results showed that the distribution pattern of fire stations in Qom is not suitable for the present situation and the time interval between the arrival of the fire trucks and the last point of the covered area is more than 5 minutes, which has 2 minutes difference with the standard time and practically one-third of the city does not have proper access to these facilities. Ziari and Yazdanpanah (2011), in a research on the site selection of fire stations in the city of Amol with using the AHP technique in Arc GIS and by studying the effective factors in the site selection of fire stations,

prepared a distance map using spatial analysis tools. Finally, using the overlapping method, the weighted criteria were combined and the optimal sites for the establishment of fire stations are determined, which showed that in addition to the existing stations (4 stations), two more stations are recommended. [Heidari and Rostami \(2014\)](#), in a research entitled "Assessment and presentation of optimal site selection for the establishment of fire stations using GIS in city of Kermanshah" showed that the construction of new fire stations in the eastern and northeast parts of this city can cover the entire city of Kermanshah in case of fire occurrence. [Mohammadi and Pourghiomi \(2014\)](#) conducted a research on spatial analysis and site selection of fire stations in the city of Noorabad using GIS. The information needed for this research was obtained through field observation and study of the land uses in relation to the city of Noorabad and the 1:5000 map of this city. [Aliabadi et al., 2017](#) conducted a research on the sitting of fire stations using the AHP and GIS compilation method in District 3 of Isfahan. Initially, effective criteria and sub-criteria for fire station sitting were weighted using Expert Choice software using AHP method. [Chen \(2006\)](#) fulfilled a research for site selecting of fire stations using GIS. This paper presents the decision support system approach for sitting fire stations through the Geodetic Database of Kadikoy District in Istanbul.

Theoretical Foundations

The main goals of urban planning can be summarized in three key concepts, health, comfort and beauty ([Sarvarzadeh and Abidin, 2012](#); [Tweed and Sutherland, 2007](#)). Urban safety topic has been used in urban planning as an optimal criterion in determining appropriate areas of activity and urban uses, along with other criteria such as adaptability, comfort, efficiency, and suitability ([Rapoport, 2016](#)). But protecting human lives, their belongings, and urban facilities against natural and human hazards is so important that it should be one of the main goals of urban planning. Natural hazards are important components of the interaction between nature and humans, and the relationship between humans and their environment ([Gibson, 1997](#)). In terms of urban planning, urban safety can include all projects and operations that protect the lives and property of city residents through short, medium and long term plans. Such programs can be used as urban land use

planning, urban zoning, seismic reinforcement and improvement of the worn-out urban fabric and for the purpose of urban safety ([Zahraei and Ershad, 2005](#)).

Urban vulnerability

Vulnerability is a term used to indicate the magnitude and extent of natural damage to societies, buildings, and geographical areas ([Alexander, 2017](#)). Assessing the vulnerability of existing buildings is in fact a prediction of their damage to possible earthquakes ([Zahraei and Ershad, 2005](#)). In other words, vulnerability is a mathematical function and is the amount of damage predicted for each element exposed to catastrophic risks, with a certain severity. Urban Vulnerability Analysis is the assessment and prediction of the probable risk of physical, financial, and spiritual damages to the city and its residents. Also the financial status of residents (as influencing factor on housing consolidation), building density (compact and irregular texture), quantity and quality of passages, building layout, high population of vulnerable strata, household number in residential unit (in relation to population density) and so on... beside structural vulnerability, are effective in increasing the casualties ([Huttenlau and Stötter, 2011](#)).

Structural planning of urban land use

Land use planning refers to the use, distribution and conservation of land ([Ziari and Yazdanpanah, 2011](#)). Urban land-use planning in action is the core of land-use planning ([Repetti and Desthieux, 2006](#)), and is a process in which the land use and the spatial distribution pattern of urban land uses are determined in order to promote the social life of citizens ([Heidari and Rostami, 2014](#)). Land use planning is an attempt to reduce the contradictions and disadvantages of environmental impacts in society and nature. Geological and geotechnical engineers need to be present in the early stages of planning decisions to provide basic information on suitable living conditions for people. In the field of geology, geologists should provide sufficient information for planners. They can help the artificial and natural environment to adapt to each other ([Abbaszadegan et al., 2011](#)).

Site selection in the city

Land use and site selection planning, population

and employment forecasting, housing and service planning, population density and optimal per capita, transportation planning, cost forecasting, investigation approaches, new city management, etc. are some of the goals and policies to construct new cities (Forman, 2008). Structural planning presented to identify structural factors and indicators and the impact of different phenomena on this part. Regarding the development of urban and rural areas with a deep view, it should be noted that in the sustainable development approach of planning requires a multidimensional image of the study area. Linking the dimensions of sustainability, especially social, institutional, economic and environmental sustainability, is a crucial issue in the sustainable development planning of rural and urban areas (Heydari and Rostami, 2014).

Spatial Distribution of Urban Services

Optimal distribution of facilities and service centers has become an important issue for planners. Due to the rapid growth of population and cities, some problems such as lack of suitable spatial distribution of facilities have arisen. In general, the demand for urban development is one of the most important problems facing humanity in the future (Ahadinejad Roosti, 2009). By investigating the inequalities in the distribution of facilities and identifying the spatial pattern of justice across the city, one can find out which facilities are more suitable and where inequalities are more concentrated in the city. In this way, urban management by conscious acting in the spatial distribution of facilities and social benefits has reduced spatial inequalities and improved the quality of life of citizens (Haase et al., 2017).

Necessity of sitting urban areas

The sitting of facility centers is particularly important in urban planning. The issue of sitting,

optimizing land uses and areas, and site selection of urban elements are important challenges in urban planning. Improper sitting can lead to some difficulties in the city (Sharifi, 2009). Optimal site selection is possible when the researcher establishes an appropriate scientific and logical relationship between the obtained information and data from the site selection experts with regard to priorities (Brink et al., 2006). Nowadays people tend to consider the place of their activities with lower cost, more profit and access to resources. On the other hand, due to the rapid growth of cities and urbanization over the past years, planning has become more important for the optimal distribution of facilities and service centers. In general, the best place to establish a facility is the one where it can make the most use of it in terms of quantitative and qualitative at the same time (Heydari and Rostami, 2014). Optimal site selection of urban services reduces the costs of urban management and access costs and leads to the social justice and welfare of citizens (Hadian and Daneshpour, 2009). In general, the main criteria for site selection in a city could be included in Table 1.

In terms of issues analysis, site selection theories are divided into three categories:

- Theories based on the cost minimization method
- Theories based on the access analysis method.

Theories are based on the method of maximizing profit and these are in fact the logical result of the two methods above.

Since most site selection models are used to find optimal sites or to design optimally, they are called site selection or sitting models. The purpose of these models is to find the best place for an activity or establishment (Meshkini et al., 2010). In assessing urban spaces, the quality of the urban environment is a priority. Here, a combination of different economic, social and biological factors and variables assess the public areas of a city. Fig. 1 shows this in detail.

Table 1: Main site selection Indicators

Cost Indicators	The cost of transportation, the workforce distribution, the place for supplying incentives or tax systems
Demand Indicators	Market areas, Spatial distribution of demand, Distribution network
Local and Regional Indicators	External facilities, financial access in areas, energy supply, access to land, etc.
Non-economic indicators	Political, social and cultural characteristics, legal conditions and constraints

(Heydar and Rostami, 2014)

Factors influencing the sitting of fire stations

The distribution pattern and site selection of fire stations in cities are among the important issues related to urban facilities, which are strongly influenced by population density and land use, the average rate of fire, size and severity of the fire, and average damage inflicted in different areas. Therefore, urban planners, by applying complete idea control specifications, try to present a suitable pattern for the distribution of fire stations on the map. Studies have shown that the following factors are involved in classifying the factors affecting the site selection of fire stations: geotechnical considerations, accessibility, useful radius of operation, population, city development, proximity and the land use and the size of the plot. The current study has been carried out in 2018 in District 12 of Tehran- Iran.

MATERIALS AND METHODS

The type of research in this study is applied and descriptive-analytical method has been used for data analysis. In this research, by identifying the optimal sitting of fire stations in city safety, understanding the status quo, general criteria and indicators for urban planning are recognized by experts and then evaluated through Analytic hierarchy process (AHP). In the next step, the fire stations layer is prepared and then for each criterion, an information layer is created in the ArcGIS software and finally, a map of the fire stations is created, which can be properly analyzed

the structure of the fire stations in the District 12 by comparing the current position with the results. The statistical population of the study includes all experts in urban planning and management who have a relative familiarity with District 12. Because of using expert opinion to assess the criteria, 30 experts who are familiar with the field of urban planning and site selection are randomly used to assess the criteria. The District 12 of Municipality of Tehran is one of the 22 District of Tehran with an area of 91.16 square kilometers, is located at 35 degrees 64 minutes to 35 degrees and 72 minutes latitude and 51 degrees 40 minutes to 51 degrees 44 minutes longitude in the central part of Tehran Fig. 2.

Selection of the research criteria

Several criteria have been used to locate the fire stations in the District 12 of Tehran:

- Using previous studies and research in sitting of fire station
- Field studies and visiting the area and combining with other sectors
- Using the principles and criteria of urban standards in site selection and sitting them

Finally, the criteria of the study are categorized into two general categories of criteria, each of which has different sub-criteria, as shown in Table 2.

RESULTS AND DISCUSSIONS

Criteria Evaluation

Criteria evaluation was done through the AHP

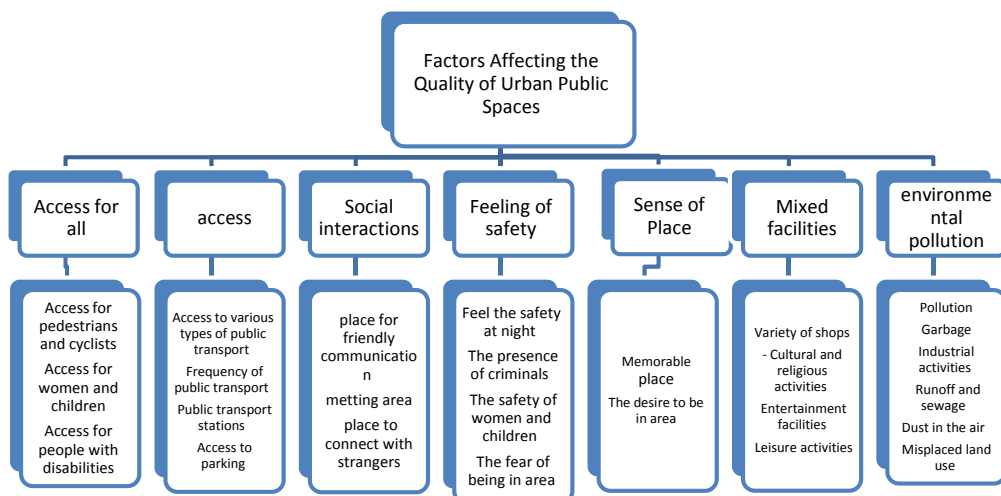


Fig. 1, Evaluation variables and factors (Meshkini et al., 2012)

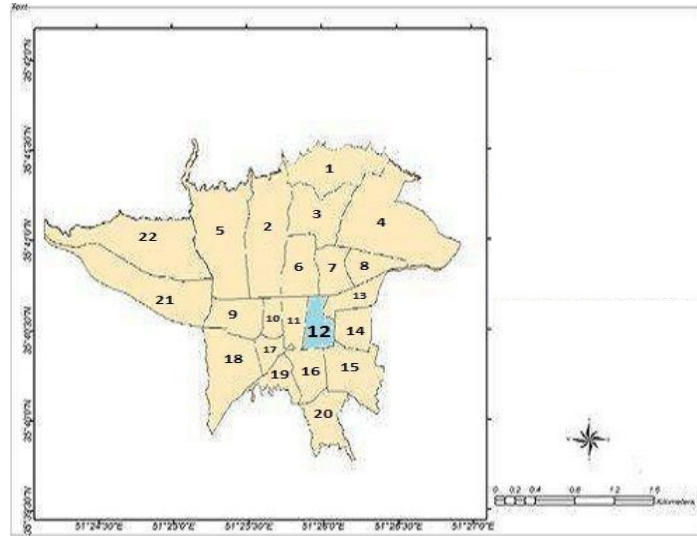


Fig. 2 Location of the District 12 of Tehran

Table 2: Site selection variables for fire stations in area 12 of Tehran

Services and urban elements	Important urban land uses
Distance from population centers and population density	Distance from residential centers
Distance from fuel centers	Distance from educational and administrative centers
Old texture	Distance from the green and recreational spaces
Proximity to storage centers	Proximity to health centers
Proximity to facilities and urban services	Proximity to historical-cultural centers
	Distance from crisis management centers
	Proximity to communication roads

Table 3: Weights of urban elements and services Criteria for site selection of fire stations in District 12 of Tehran Based on AHP method

Criterion	Weight
Proximity to urban facilities and services	0.333
Distance from population centers and population density	0.256
Old texture	0.231
Proximity to storage centers	0.95

Table 4: Weights of urban elements and services Criteria for site selection of fire stations in District 12 of Tehran Based on AHP method

Criterion	Weight
Distance from crisis management centers	0.191
Distance from communication roads	0.191
Proximity to health centers	0.191
Distance from residential centers	0.191
Distance from the green and recreational spaces	0.112
Distance from the administrative-cultural centers	0.069
Proximity to economic centers	0.054

method and Expert choice software. At first, a set of criteria was presented to the relevant experts in the form of a questionnaire and then pair comparison

was made based on the structure of the model. Then the median of the expert data was calculated and the final result was entered into the software. [Table](#)

3 presents the results of the criteria weights in the elements and urban services section. Accordingly, proximity to urban services and facilities and distance from population centers are of greater value.

Table 4 illustrates the weight of the sub-criteria of urban uses criteria. Four of the sub-criteria including distance from crisis management centers, communication roads, residential centers and proximity to health centers are of great importance.

Based on Table 5, which shows the weight and final value of the sub-criteria, distance from crisis management centers, proximity to communication roads, proximity to health centers, proximity to urban facilities, and distance from residential centers are of

the highest importance for site selection and sitting fire stations in District 12. Also, the results of the AHP method showed that urban land uses have a higher significance and weight in site selection of fire station. In fact, according to the experts, urban lands have more priority than urban services and facilities for fire stations.

Internal valuation of sub-criteria in information layers

After determining the final weight of each sub-criterion, an information layer is created in ArcGIS software for each sub-criterion to sitting the fire stations. In the next step, the created layers are valued based on the value of each section of District

Table 5: Total weight of site selection criteria of fire stations in District 12 of Tehran Based on AHP method

Criterion	Weight
Distance from crisis management centers	0.122
Proximity to communication roads	0.122
Proximity to health centers	0.122
Proximity to urban facilities and services	0.122
Distance from residential centers	0.122
Distance from population centers and population density	0.094
Old texture	0.084
Distance from the green and recreational spaces	0.071
Distance from the administrative-cultural centers	0.044
Proximity to storage centers	0.035
Proximity to economic centers	0.034
Distance from refueling centers	0.031

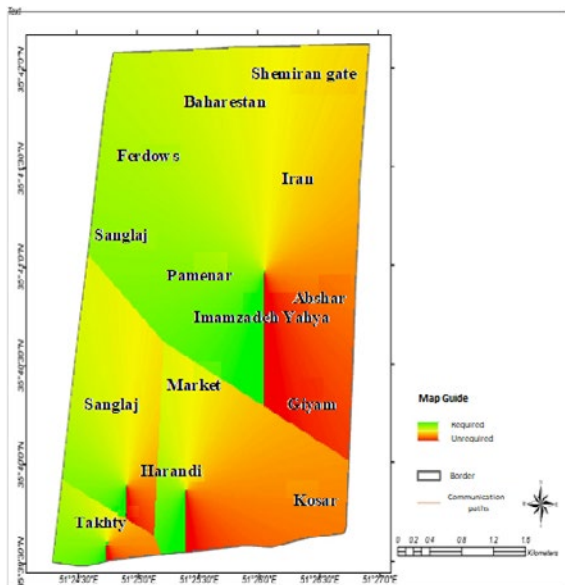


Fig. 3: Distance map of the refueling centers in the District 12

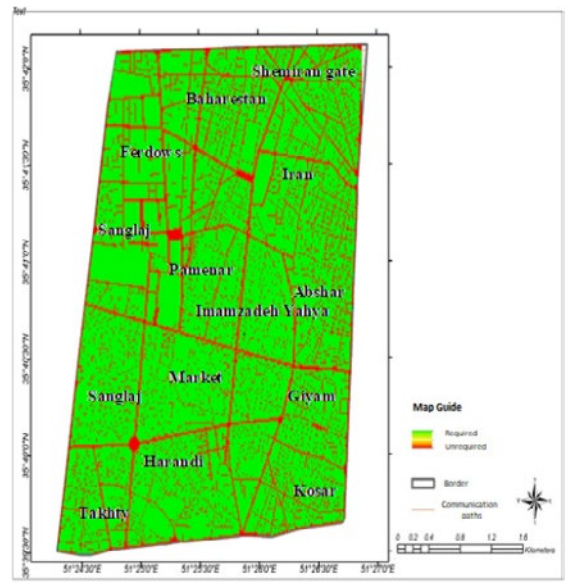


Fig. 4: Distance map of the populated centers and population density of the District 12

Site selection of fire stations

12 so that in the software more value is assigned to the sites in District 12 that are suitable for sitting the fire stations. This is done through fuzzy logic. In this way, the most suitable sites for the sitting fire stations are assigned values of 1 and close to 1, and for unsuitable sites values of 0 and close to 0, and finally, the maps are classified by the degree of suitability to unsuitability. In order to internal valuation of the layers, fuzzy logics were used.

Distance layer from population centers and population density

Layer of populated centers and population density is referring to residential areas and populated areas of the district as well as economic centers such as markets and passages and squares and terminals, which are the center of the attraction of passengers and people gathering. Considering the high population of the district and the existence of political, cultural and historical centers and important shopping centers, etc., most of the areas of this district are very populated and in the process of fuzzy mapping, most of the district has high membership logic, and these sites are suitable in terms of establishing fire stations (Fig. 4).

Distance layer from Refueling centers

The Refueling centers are gas and gasoline

distribution centers in the district. The two layers of this two centers were merged together and then merged through fuzzy logic (Fig. 3). According to the principles of site selection of fire stations, areas closer to the refueling centers are more suitable due to the providing services to the fire trucks and in the fuzzy logic should be assigned values close to 1 for these areas. As shown in Fig. 3, the center and the northwest areas of the District including Pamenar and Sanglaj, Ferdous and Baharestan are suitable sites.

Distance layer from old texture

The old textures of the District are mainly located in the central and southern parts of the District, as shown in Figs. 5 and 6. Sanglaj, Bazar, Harandi and Takhty neighborhoods are considered to be the old textures of the district. For site selection of the fire stations in the District, it is essential that the stations be close to these area because the risk of hazard in these areas is greater than other areas.

Layer of proximity to storage facilities

Warehouses are centers for maintenance of various urban facilities that are also used for the maintenance of firefighting equipment. For site selection of the fire stations in the District, it is essential that the stations be close to these warehouses to provide extra

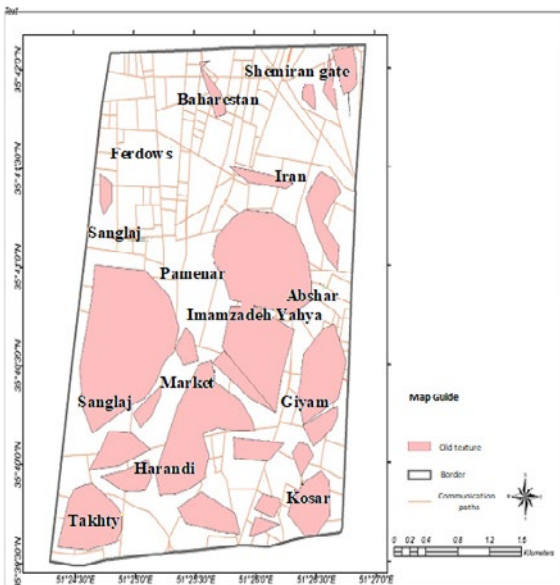


Fig. 5: Distance map of old texture in the District

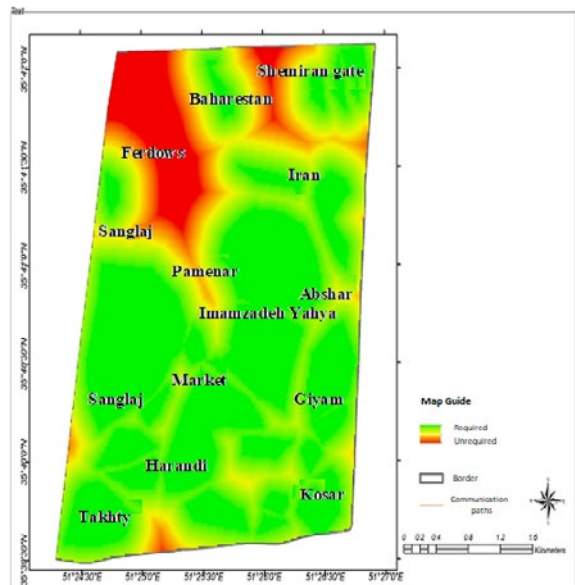


Fig. 6: Fuzzy layer of old texture in the District

facilities in the crises situations. According to Fig. 7 the northern and northeastern parts of the area are the suitable areas for establishing fire stations.

Layer of proximity to urban facilities and services

After preparing the urban services layer, the distance layer of these services was created and its suitability

was measured for the site selection of the fire stations. In general, areas close to the urban services are suitable for the establishment of fire stations, and in Fig. 8, their fuzzy membership is close to 1.

Distance layer from communication roads

In this part, the main and important communication

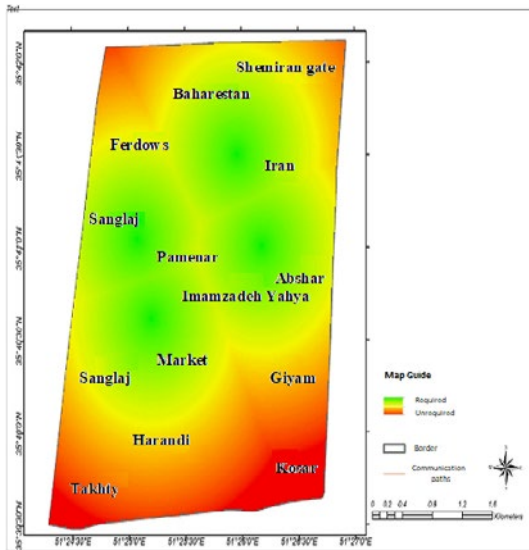


Fig. 7: Fuzzy layer of distance from Storage Centers

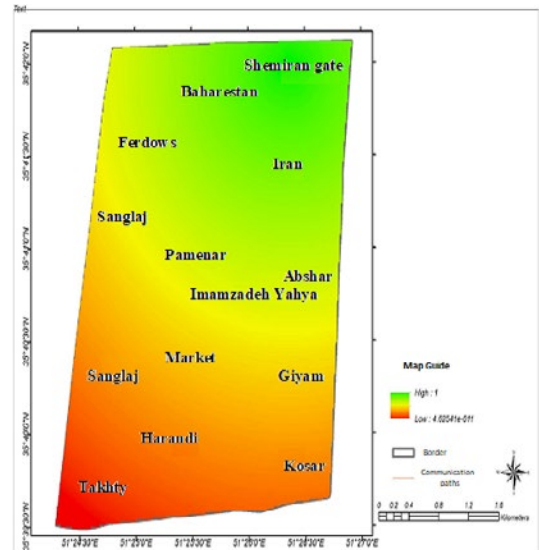


Fig. 8: Fuzzy layer distance from urban facilities and services

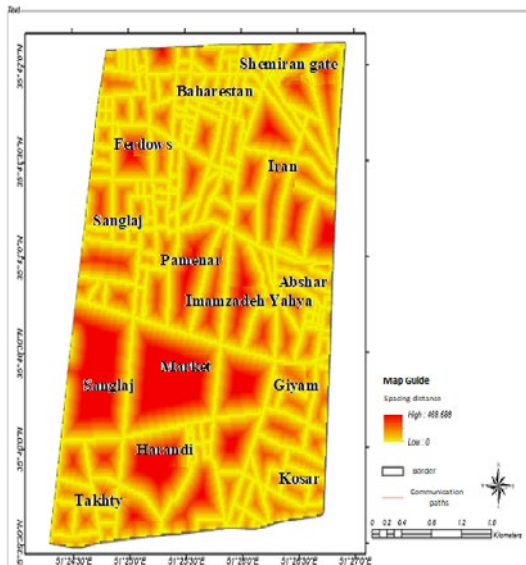


Fig. 9: Distance from communication roads of the District

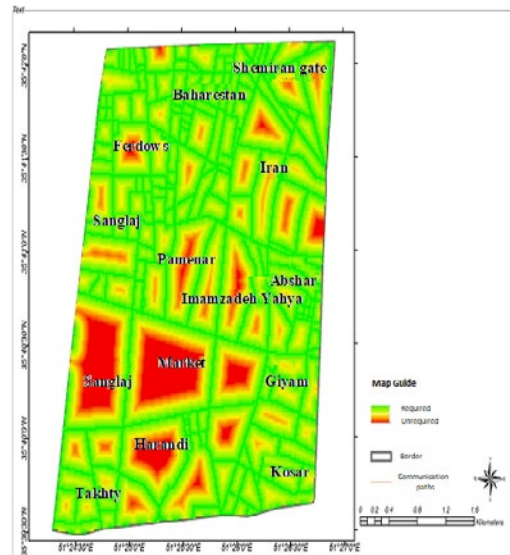


Fig. 10: The fuzzy layer of the distance from communication roads of the District

roads of the District have been considered. The important roads of the Districts play a prominent role in the rapid transportations of firefighters, and it is essential that stations be sitting in the adjacent to these roads. The main roads of the District are in central and northern parts and obviously, these areas are more suitable to construct the stations, but at the same time, most of the areas in the District are suitable (Figs. 9 and 10).

Distance layer from crisis management centers

Crisis Management is of great importance and can be examined in several ways, but this study addresses two important parts:

- Specialized centers for Crisis Management;
- Existing fire stations

In Figs. 11 and 12, the fuzzy layers are indicated for these two parts. Specialized centers for Crisis

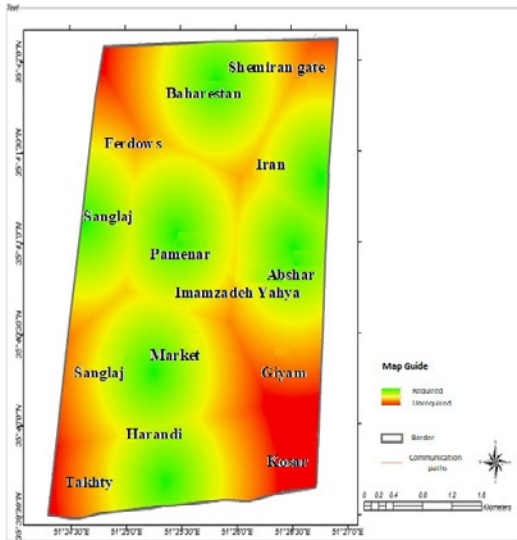


Fig. 11: Fuzzy distance layer from crisis Management centers

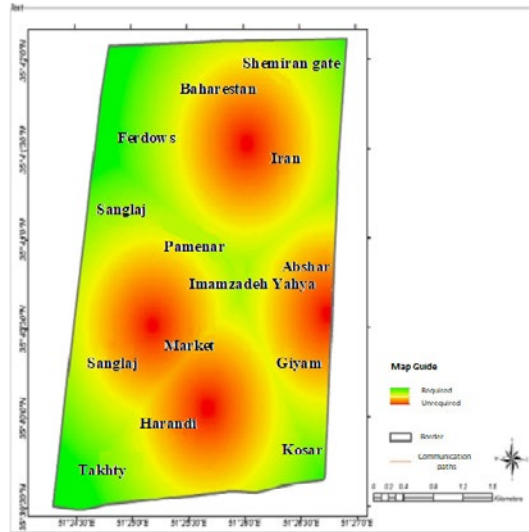


Fig. 12: Fuzzy distance layer from fire stations

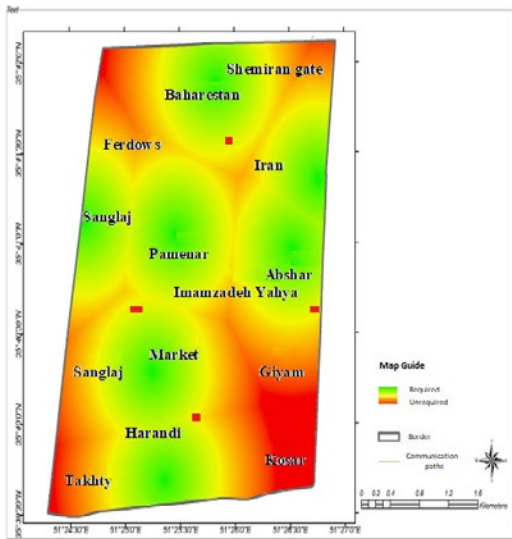


Fig. 13: Fuzzy distance layer from crisis management centers in district 12 of Tehran

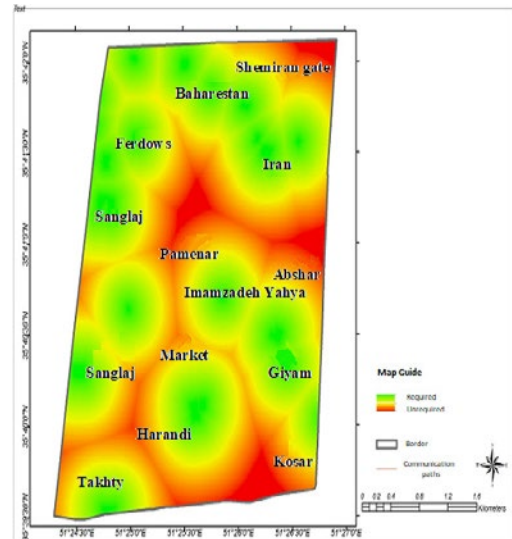


Fig. 14: Fuzzy distance layer from health centers in the District 12 of Tehran

Management are located in the center and a few are located in the western and eastern parts of the District. It is more suitable to construct new fire stations near to these parts. Also, the same condition applies to current fire stations, and it is necessary to have new stations adjacent to these fire centers. Finally, both fuzzy layers were combined and the final fuzzy layer of crisis management centers was

prepared for site selection of fire stations in the District 12 (Fig. 13).

Distance layer from health centers

Health centers including hospitals and clinics are very important in terms of handling victims and moving them quickly to health centers and reducing casualties. However, new fire stations should be in

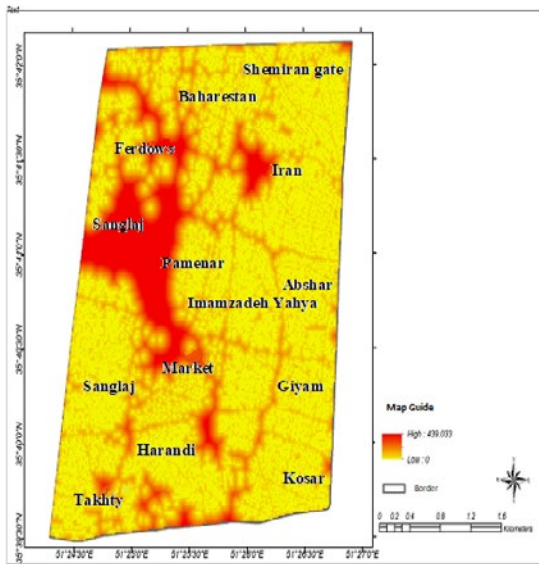


Fig. 15: Raster distance layer from residential centers of the District

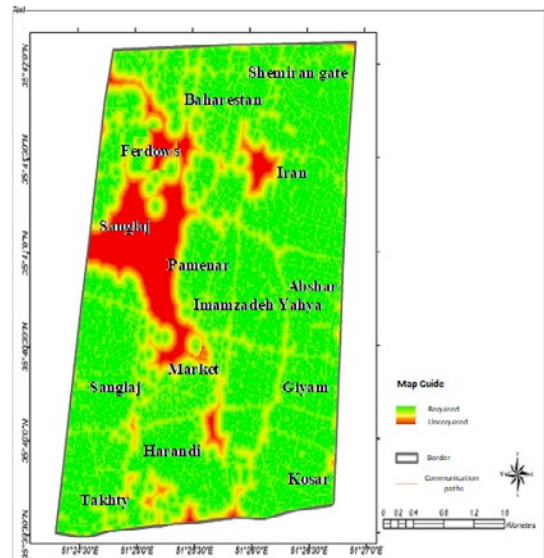


Fig. 16: Fuzzy distance layer from residential centers of the District

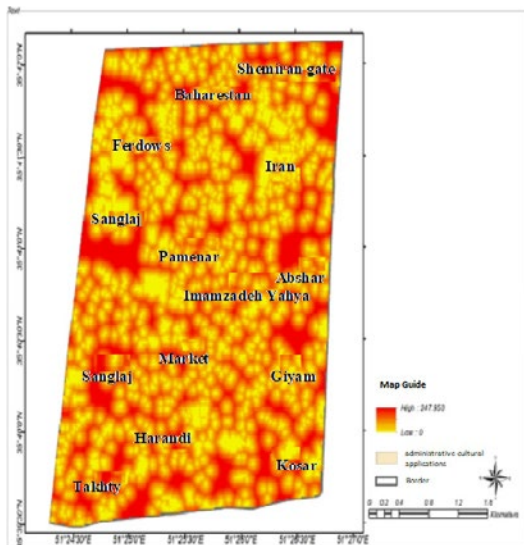


Fig. 17: Raster distance layer from administrative-cultural centers

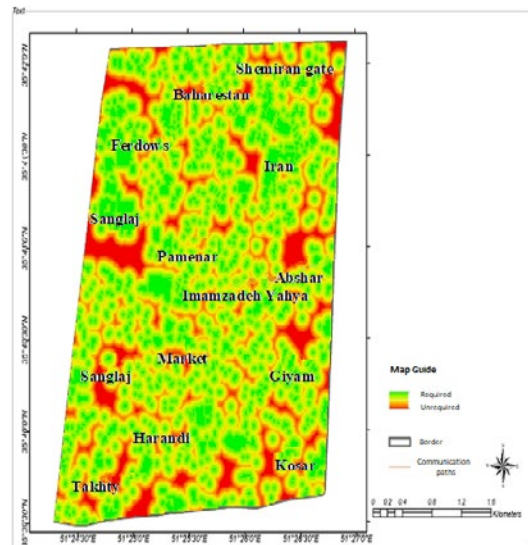


Fig. 18: Fuzzy distance layer from administrative-cultural centers

Site selection of fire stations

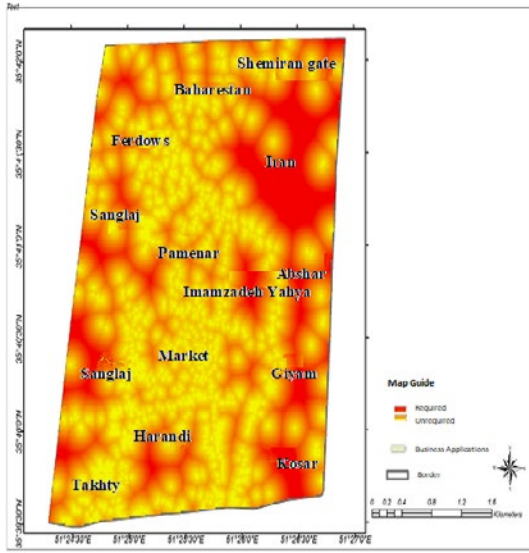


Fig. 19: Fuzzy distance layer from economic centers of the District 12

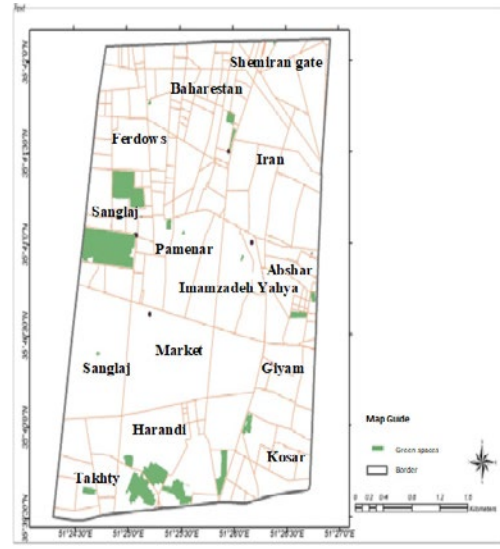


Fig. 20: Green spaces map of the District

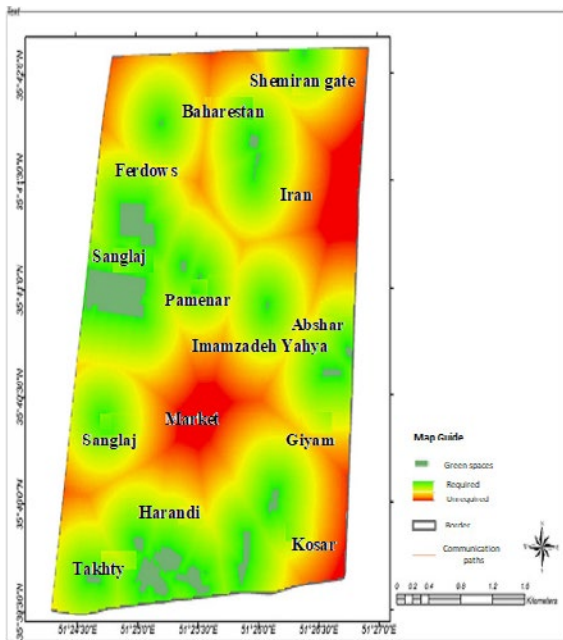


Fig. 21: The fuzzy layer of green spaces of the District

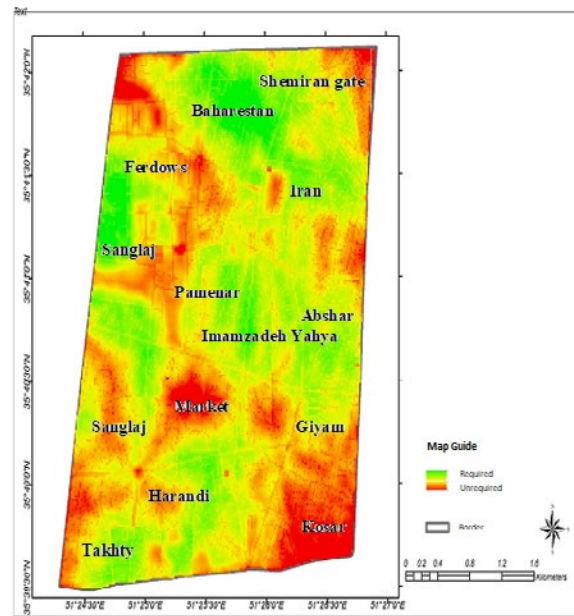


Fig. 22:- The final map of the suitable sites for construction of fire stations in the District 12

the adjacent of these facilities and centers. Based on Fig. 14, the neighborhoods of Giyam, Harandi, Baharestan and Ferdows in the district have suitable conditions for the establishment of new fire stations.

Distance layer from residential centers

Residential areas are important because of the high population density and it is also a high-risk sector in the field of fire accidents, etc. and is highly

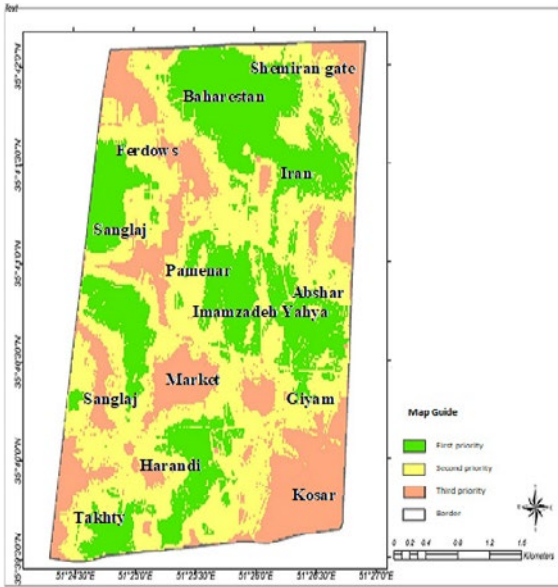


Fig. 23: Prioritization of suitable places for the construction of fire stations in the

probable of casualties therefore, requires high-speed emergency services. Accordingly, fire stations should be located adjacent to residential areas. Except Ferdows, Sanglaj and Bazar, the rest of the area are suitable for constructing the fire stations (Figs. 15 and 16).

Distance layer from administrative-cultural centers

This criterion consists of two parts:

A set of administrative and educational centers, such as offices and schools;

A set of cultural centers including cultural and historical places;

First, the layers of these two parts were separated from the land-use layer and the distance layer was created from the two layers, then these layers were combined and finally, the fuzzy layer of administrative-cultural centers was created (Figs. 17 and 18). As a matter of fact, proximity to these places and centers is an advantage and suitability for the site selection of fire stations. The cultural and administrative centers are distributed in different parts of the District and, accordingly, the suitable sites are distributed in the district.

Distance layer from economic centers

Economic centers include a set of commercial and economic places such as markets and shopping complexes. Basically, because these areas are the

center of population density, it is necessary to have fire stations in the vicinity of these parts. Economic centers extend in the shape of stripes from north to south, and such land uses are less common in the eastern and western parts (Fig. 19).

Distance layer from green spaces

Fig. 20, shows the urban green spaces including parks and recreational areas of the district. These spaces are also a gathering centers for people and it is important to construct fire stations in the vicinity of these areas. Fig. 21, shows the fuzzy layer of the green spaces of this District. In general, the green spaces of the District are near the Takhty, Sanglaj and Ferdows neighborhoods. Obviously, these areas and their adjacent areas are more suitable in terms of site selection for fire stations.

The final layout of site selection of the suitable places to constructing fire stations

After determining the effective factors in sitting fire stations in the District 12 of Tehran and providing all necessary information in the GIS and determining the weight of criteria and sub-criteria effective in sitting and classifying the layers, using the capabilities of the ArcGIS software, the maps and information layers were prepared, combined and overlapped, and then weights obtained from the Weighting step of the AHP method were applied to each of the layers, and finally a site selection map for the district was prepared. Figs. 22 and 23 show the final layers and areas suitable for the establishment of fire stations.

According to the results of Fig. 22, the most suitable areas and sites for the establishment of fire stations in the district can be summarized as follows:

- Areas near to Imamzadeh Yahya and Pamemar;
- The northern areas of Baharestan neighborhood;
- The Harandi and Takhty areas

Also, according to the results of Fig. 23, Prioritization of suitable places for the construction of fire stations will be as follows:

Priority One: These areas, which are the first priority of investment and planning for the construction of fire stations, include the following areas: 1- Harandi and Takhty neighborhoods 2- Baharestan neighborhood 3- Imamzadeh Yahya neighborhood. These areas are the first priority for the construction of new stations due to their proximity to the road, residential areas, the existence of medical and commercial centers,

along with the existence of old texture structures.

The second priority: these areas are circularly drawn to the first priority zone and are in the second priority for planners: - Ghiam and Abshar neighborhoods, - Sanglaj neighborhood, - Ferdows neighborhoods and Darvaze Shemiran.

Third priority: These spaces are basically suitable for establish fire stations, but naturally, each district requires the establishment of a fire station and these areas are in the last priority: - Tehran Bazar, Kowsar neighborhood, areas between Pamenar and Sanglaj, and areas adjoining to Ferdows neighborhood.

CONCLUSION

In the present study, evaluation of the criteria was done through AHP's hierarchical analysis process and Expert choice software. The results showed that the criteria for proximity to urban services and facilities and population centers are more important than other criteria. Including distance from crisis management centers, proximity to communication routes, proximity to health centers, Close proximity to utilities and distance from residential centers are of the utmost importance for locating fire stations in the District 12. The results of the AHP model also showed that urban land uses have a higher importance and weight for construction of fire stations. In fact, according to experts, urban land uses have the priority over the areas which were determined for urban services and facilities. Based on the results of the fuzzy maps, the central population layer comprising residential areas, densely populated areas, economic centers as well as Tehran Great Bazar, including tourist areas, and centers, can be important in establishing the fire stations. According to the principles of locating fire stations near fuel centers, are more desirable for the mentioned service purposes, and the need to establish fire stations near worn-out tissues, mainly in the central and southern parts, is more urgent. Warehousing facilities for municipal equipment and installations in the northern and northeastern parts of the area have also been identified as suitable for the construction of fire stations. High access points to the central and northern sections of the district, as well as proximity to the crisis management centers in the center, and western and eastern sections are also important sites for the construction of these stations. Proximity to health centers and areas with high buoyancy populations (Tehran Great Bazar) and residential areas

are also priorities for proximity to stations. Another factor is the distance from the economic centers, which, according to fuzzy drawing maps, are drawn from the north to the south, with less economic use in the western and eastern parts. Establishment of fire stations in the proximity of green spaces, which are generally parks near the Takhty, Sangalaj and Ferdows areas are also suitable for the purposes in mind.

The final word is that, rather than establishing crisis management and fire stations in high-risk areas, it is best to reduce the risk in the area first. In urban planning, all the planning should be based on the suitability of the areas, not just with the top priority areas. In fact, each area must be assessed for its shortcomings and suitability and accordingly, suitable sites would be selected. In relation to District12 safety planning must be done in connection with other aspects of urban planning and more emphasis must be put on the principles of safety and crisis management in selection and placement of urban facilities with view point to the public welfare and social justice principles.

Suggestions

Conducting research on the principles of architecture and safety of urban buildings in the District of 12 of municipality of Tehran;

Conducting research on renovation and remodeling of worn-out tissues of the District 12 to reduce potential casualties;

performing feasibility study of relocation of existing fire stations based on the current study in the area;

Conducting a feasibility study of sit selection for building new fire stations in the adjacent districts in order to perform combinatorial rescuing operations in the emergency situations from neighboring districts and vice versa.

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CONFLICT OF INTREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. In addition, the ethical issues; including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission,

redundancy have been completely observed by the authors.

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