

Research Article

Evaluation of the Performance of Vital Services in Urban Crisis ManagementFaraz Estelaji ¹, Alireza Naseri ², Rahim Zahedi ^{3,*}

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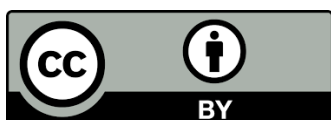
* **Correspondence:** Rahim Zahedi; E-Mail: rahimzahedi@ut.ac.ir**Academic Editor:** Zed Rengel**Special Issue:** [Environmental Management](#)*Adv Environ Eng Res*

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Received: October 08, 2022**Accepted:** December 19, 2022**Published:** December 26, 2022**Abstract**

Crisis management assessment and planning include many components. One of the essential elements is the review and analysis of the structure of the existing situation and the performance of Vital services in the face of critical cases. During the occurrence of natural disasters, the issue of crisis management is crucial in order to reduce the damages caused by the crisis. One thing that reduces the damages is the correct and timely access of critical relief centers such as fire departments, emergency, police force, and crisis management centers to their covered areas. Therefore, in this research, the structure of these vital centers' existing situation and location were investigated first, and the operating radius of these centers was measured according to specific standards. In this research, Network Analyst has been used to analyze 8300 streets, taking into account the average speed limit and the length and width of each street in the GIS to calculate the level of coverage of vital relief agencies. This system uses the Dijkstra algorithm to find the best route, the most straightforward algorithm among



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all existing algorithms. It also has high power and speed in calculations. In this article, after analyzing the performance of four vital services during crisis management in terms of accessibility and zoning, and prioritization based on the level of high, medium, and poor coverage, and according to the obtained results, it is suggested that a new location for creating new service centers should be established in areas with poor coverage so that the balance in the field of relief is done in the face of future crises. Other urban researchers can use this approach.

Keywords

Crisis management; network analyst; level of performance; Tehran

1. Introduction

After natural disasters such as earthquakes, the performance of communication networks decreases significantly due to the collapse of buildings and the possible closure of communication routes [1]. At this time, communication networks and access to relief centers play a vital role in saving human lives [2]. For this purpose, the optimal distribution of utilities and relief centers is a problem for urban planners [3]. Due to the rapid population growth and the cities' size, there have been problems, such as the lack of suitable space for relief centers [4]. Today, the geographic information system (GIS) is a helpful tool for creating a unified and efficient database [5]. One of the primary goals of policymakers in the field of health in any country is to facilitate people's access to health care services so that all sections of the society can benefit from these services optimally, hence the level of performance and coverage of relief centers is essential to reduce human casualties [6]. Crisis management should not be considered only as a tactical response when a disaster occurs but as preventive activities within processes related to crisis prevention [7]. Therefore, the location of public facilities is an example of government policies that understand the benefits of saving resources, increasing the efficiency and synergy of services, especially during a crisis, and increasing the sense of collectivism. Such benefits are especially critical for governments experiencing rapid population growth [8].

Crisis management assessment and planning include many components. One of the essential elements is to review and analyze the structure of the existing situation and the performance of vital services in the face of critical cases. During natural disasters, the discussion of crisis management is critical to reducing the damages caused by the crisis. One thing that reduces the damages is the correct and timely access of critical relief centers such as fire brigade, emergency, police force, and crisis management centers to their covered areas. Therefore, the main direction of the research is the answer to the question, what is the current structure of critical services in crisis management in terms of operating radius, and what are their priorities in terms of zoning and efficiency?

2. Background

A crisis is an event that occurs suddenly as a result of natural and human events and actions, imposes hardship on a group or human society, and its elimination requires emergency, urgent and

extraordinary measures [9]. One of the crisis management solutions in urban settlements is to pay attention to communication routes [10]. The crisis is usually described as unexpected events [11]. An unexpected incident becomes a crisis when resources beyond the local resources are needed to contain and manage it. With this definition, a crisis usually leads to extensive destruction and destruction [12]. A simple and general definition of a critical situation is: A critical situation is a situation that occurred due to a specific incident so that the usual organizations cannot deal with it with the available resources and facilities [13]. In other words, it is beyond the capacity of existing organizations. Such crises usually occur due to natural disasters; their effects are dangerous, destructive, and deadly, at least potentially and often in practice. The word "disaster" is a combination of two words: dis, disturbing, without, against, and Astrum, which means star, fortune, and horoscope. The familiar words in this field are the event event's consequences: accident, incident, disaster, and crisis. Today, the definition of crisis refers to the sum of natural and human activities. One of the definitions of crisis is a severe disruption in the functioning of society that has caused extensive human, resource, and environmental losses. These losses exceed the ability of society to reconstruct this definition. It provides a better understanding of the various causes of accidents involved in the catalytic processes. It refers to the interaction between natural events and the physical environment and their role in a crisis [14].

Shirali et al. [15] presented a new framework for assessing crisis management based on resilience principles in the hospital infrastructure of a developing country. They developed a questionnaire and completed it by 310 staff (nurses and managers) of eight hospitals in Iran. In another study, Salehi et al. [16] suggested an integrated entropy-TOPSIS approach as it is appropriate to achieve the defined aims. They also ranked five petrochemical plants and assessed their crisis management systems. The assessment of crisis management systems was performed in terms of technical, human, and organizational aspects. Dijkstra's algorithm realizes the so-called greedy approach, which means that in each iteration, it selects one of the nodes not visited yet that may be accessed at the lowest cost. The algorithm selects locally optimum solutions, which means that it does not analyze whether it is reasonable to perform a given action in the subsequent steps of the process. The Dijkstra algorithm is described in detail in [17].

Crisis management is a systematic process during which the organization tries to identify and predict potential crises and then take preventive measures against them to minimize their effect. The three-stage crisis model seems to be comprehensive. This model, which is shown in Figure 1, consists of three stages: before the crisis, during the crisis, and after the crisis. The pre-crisis stage includes all measures to prevent the crisis, and the during-crisis stage, relates to the steps to respond to and deal with the crisis. And the post-crisis stage includes ensuring the resolution of the crisis and the security of the organization and learning from the event to prevent its recurrence. A crisis is a disruption that physically affects the entire system and threatens its vital axis.

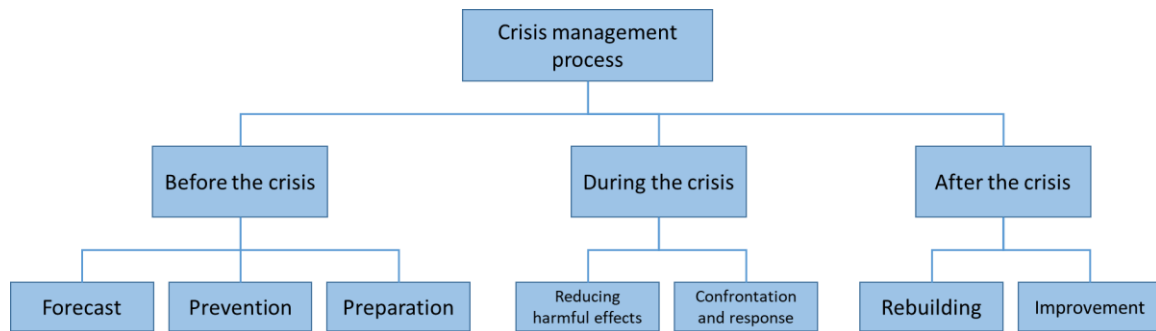


Figure 1 Crisis management process.

Each of the crisis management processes is as follows:

Forecasting: It is a set of measures taken before a crisis to prevent the occurrence of risk or reduce its harmful effects [18].

Prevention: A significant step in the crisis management process after the prediction stage. Many crises can be prevented, or their severity can be reduced. Prevention is all the activities related to avoiding and staying away from the harmful effects of risks, which minimizes the disasters and losses related to that risk.

Preparedness: It is a set of actions that increase the ability of society to perform different stages of crisis management [19].

Confrontation: Providing emergency services after a crisis saves customers' property and prevents the spread of damages [20].

Reconstruction and improvement: Actions to restore the conditions of the organization affected by the crisis to normal conditions. The first step is to clear the crisis environment of any signs and evidence of the crisis. This stage is called restoration, improvement, rehabilitation, and redevelopment [21].

By using GIS, it is possible to identify the vulnerable points against the crisis before the occurrence of various disasters. In recent years, GIS has been used as a powerful tool in the crisis management of natural disasters such as earthquakes, storms, tornadoes, floods, etc. This technology makes the information needed for crisis management planning available to managers. On the one hand, before a crisis occurs, it is possible to identify more vulnerable areas and empower those areas. On the other hand, natural disasters such as earthquakes, storms, tornadoes, and floods occur. It is necessary to carry out various operations to save people, such as introducing shelters, and medical supplies, creating rescue stations and routes, awareness of people, etc., to minimize damages [22]. For this purpose, it is necessary to have various information in one center to be available as soon as possible. Different organizations in the country can use GIS to share their information so that they have comprehensive and up-to-date information and can provide services better and faster when a crisis occurs [23].

3. Methodology

The type of research is Practical in terms of purpose and survey and exploratory in terms of method. Analytical descriptive research is also called survey research. The descriptive method shows data in charts, figures, maps, and tables. According to the nature of this research and its questions, the present research is also considered exploratory research in terms of methodology.

This research uses the method of collecting library and documentary information and conducting interviews and field observations. Among the tools of information collection in the library method in this research, we can mention the use of books, articles, theses, standards, and basic maps. The field method in this research was conducted in district 10 of Tehran city. All the critical relief agencies of District 10, including the fire department, emergency, crisis management centers, and police force, were visited. Also, experts and experts in crisis management centers of region ten were interviewed, information was collected, and the Network Analyst tool was used in the GIS environment to calculate the level of coverage of vital relief services. Today, the use of Network Analyst tools in relief operations has attracted much attention [24]. Network Analyst is a compelling extension of Arc GIS in spatial analysis, including routing, determining the coordinates and direction of movement, finding the closest points to public services and determining the location of public services, finding the shortest route in terms of time and distance, and displaying the coverage level of relief centers [25, 26]. This software allows the user to create a dynamic and realistic model by creating a network of roads, which includes the application of turning restrictions, height restrictions, speed restrictions, and traffic conditions at different times of the day [27, 28]. This software uses Dijkstra's algorithm to find the best route [29]. Dijkstra's algorithm is the most straightforward algorithm among all existing algorithms. It also has high power and speed in calculations [30]. This algorithm can classify the possible routes based on two criteria:

1- **Distance:** Based on this criterion, only considerations of location and shortening of distances are raised [31].

2- **Time:** It can determine the driving time on each road and optimize this time based on traffic, type of route (main or side streets or alleys), the streets' average speed, and route length [32].

The advantages of this software include the following:

- Ability to display quality information based on layers of information;
- Urban traffic modeling;
- Find the shortest path;
- Display the level of coverage;
- High power of information analysis;
- Quick analysis of routes;
- Ability to compare with existing routes;
- Calculation of detailed route information, such as the length of routes and component maps of each route;
- Ability to quickly correct routes and simulate actual routes with street routes in case of obstacles or any natural terrain;
- Ability to receive routes from AutoCAD software [33].

4. Case Study

This area leads from the north to Azadi Street, from the south to Qazvin Street, from the east to Shahid Nawab Safavi Highway, and from the west to Shahidan Street [34]. Also, this area is located in the western part of Tehran and is adjacent to districts 2 (north), 9 (west), 17 (south), and 11 (east). Out of the 817 hectares of the area, 461 hectares, or 57%, is for residential use; compact structure with tiny pieces of land in this area has occupied a significant area. Therefore, in this area, we see the predominance of residential use over other urban functions; Because compared to the average

of this amount in Tehran or big cities, 57% is a very large shape. An area of 203 hectares, or 25%, is dedicated to roads and accesses. The rest of the area, i.e., 142 hectares or 18%, is dedicated to other uses, including green spaces, services, industries, and workshops [35]. The region's population is about 327 thousand people with a gross population density of about 395 people per hectare, considered one of the densest areas of Tehran among the 22 regions. Its population is four times the standard limit and twice the average density of the city [36]. This district consists of three regions, and in this research, the coverage level of relief centers in these three regions has been investigated. The study area descriptions are shown in Figure 2 and Figure 3.

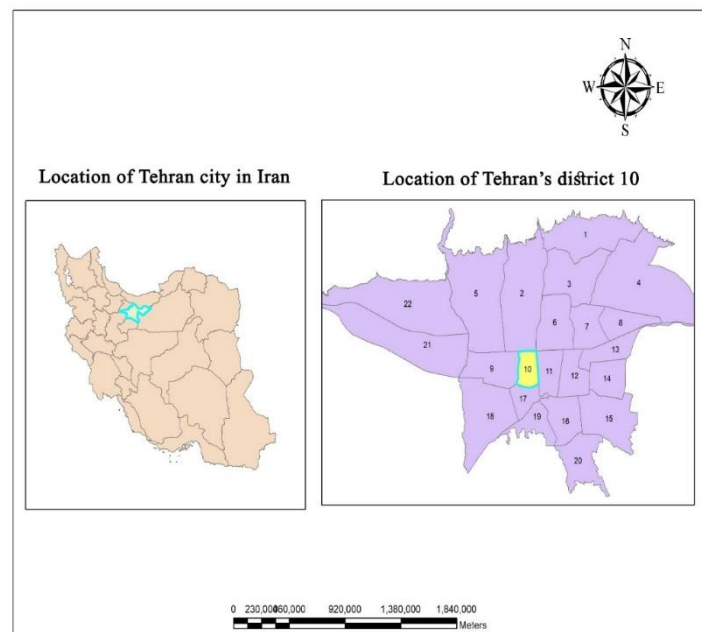


Figure 2 The location of District 10 of Tehran on the map.

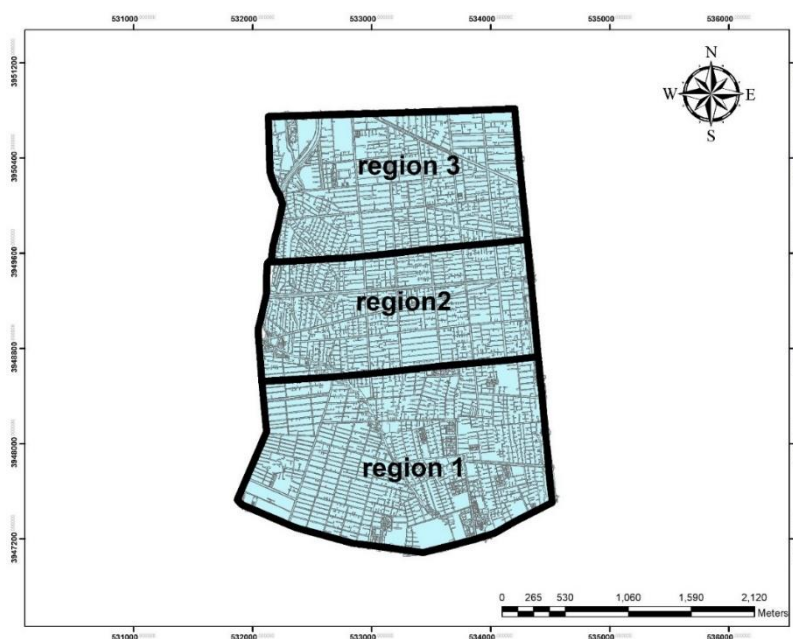


Figure 3 Districts of District 10 of Tehran.

5. Results and Discussion

A city's road network is an example of edges (links). The edges are connected through intersections, and traffic flows through them. Since the complications in the network have shape and geometry, such a network is called a geometric network. In general, for the analysis of the road networks of district 10 in this research, we have two types of complications:

1- Edges (Edge feature sources): Edges form the framework and structure of the network model and display interconnected linear features that are considered transportation and communication channels. These connections represent real-world structures such as primary and secondary streets. They are connectors on which vehicles are moving. In (Figure 4), 8300 Communication Street of Region 10 entered Network Analyst as an edge.

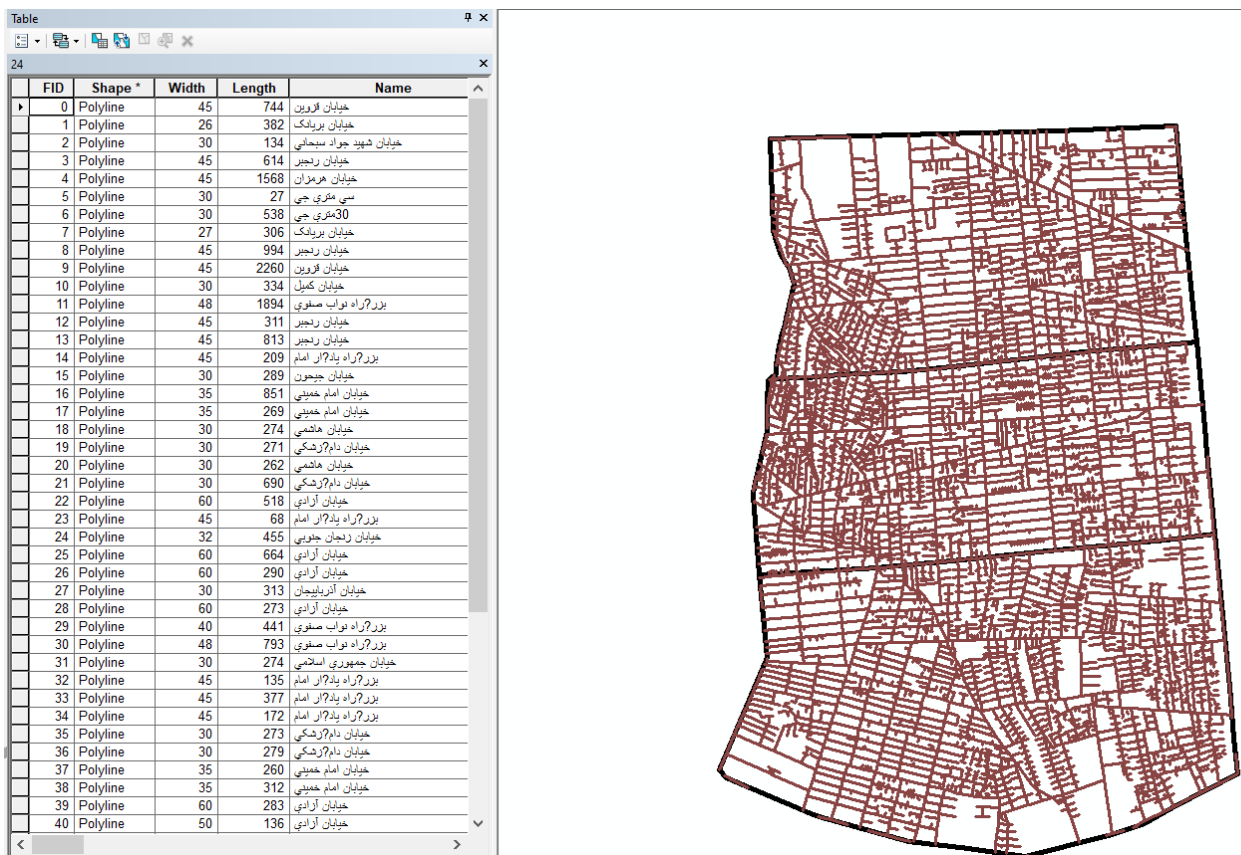


Figure 4 Importing edge effects in Network Analyst.

2- Network Nodes: Network nodes are the endpoints, initial and intersection points of the network edge. The network edge is always connected through network nodes. Nodes may also be used to model network elements such as hubs, stops and turns, fire stations, emergency, law enforcement, and crisis management centers. The complications of the node in Network Analyst are shown in Figure 5.

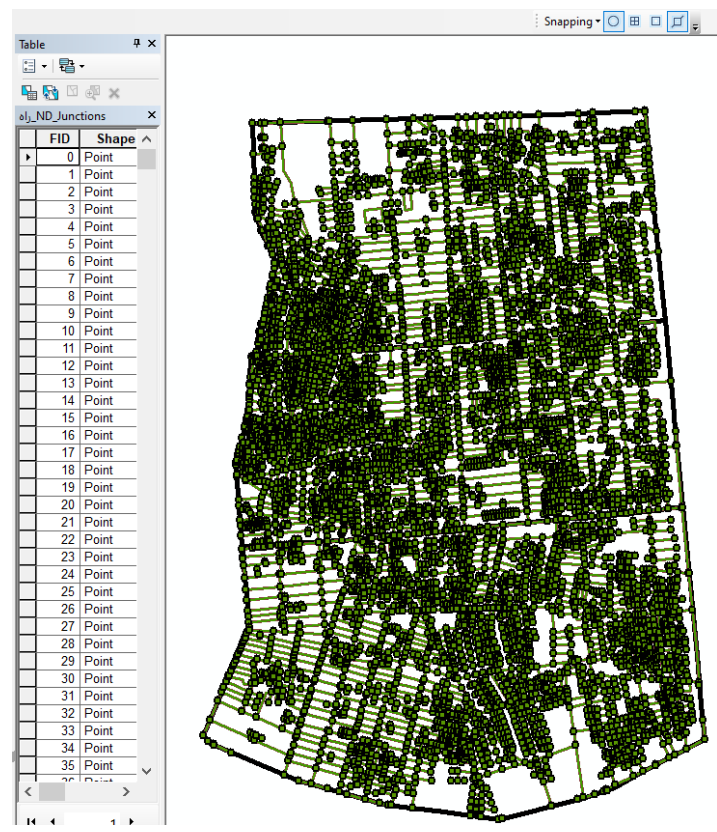


Figure 5 Enter the complications of the node in Network Analyst.

In general, the level of coverage of critical relief centers is essential from the point of view of crisis management. Examining the structure of the current situation in the studied area shows that district 10 includes seven medical centers, two fire stations, two crisis management centers, and three police stations to provide services in this area. In Figure 6, the location of each of these centers is shown.

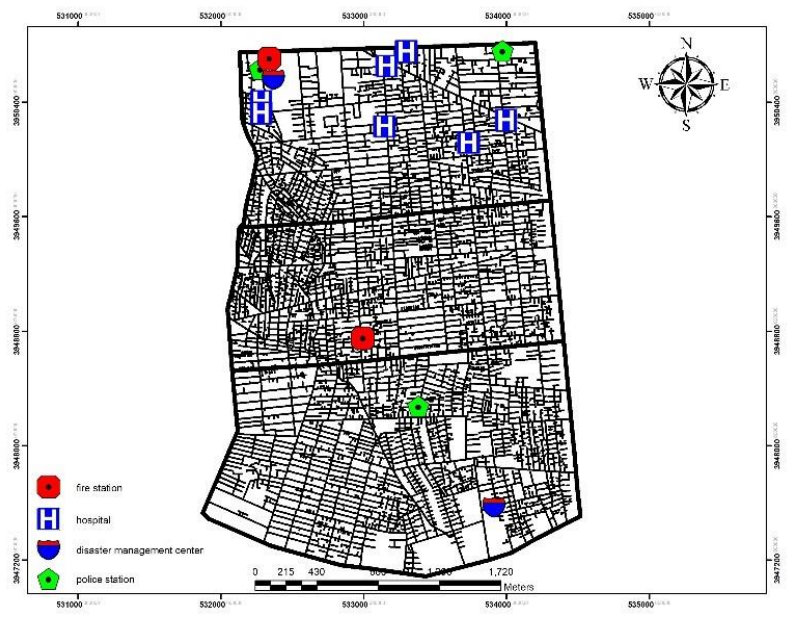


Figure 6 The location of effective infrastructures during the crisis.

5.1 Fire Station Performance Level

Based on the principles of ((maximum access)) and ((minimum time)), international standards have considered the time to reach the fireplace as 3-5 minutes (the time between the start of the fire and the start of the firefighting operation). Considering the loss of one minute for the fire message to reach the station and the cars leaving the station in the remaining 2-4 minutes, we checked the coverage level [37]. The status of the study area in terms of the accessibility of the fire stations for the 10th district of Tehran is shown in Figure 7. There are two fire stations in this district, and according to the obtained map, the fire station access to region two excellent condition. The fire station access to region three is in good condition, but according to the map, the access of fire stations to the southern areas of region one is not in good condition. In general, 162 hectares of the entire area are under excellent service level, 405 hectares are under good coverage, and 250 are under poor coverage.

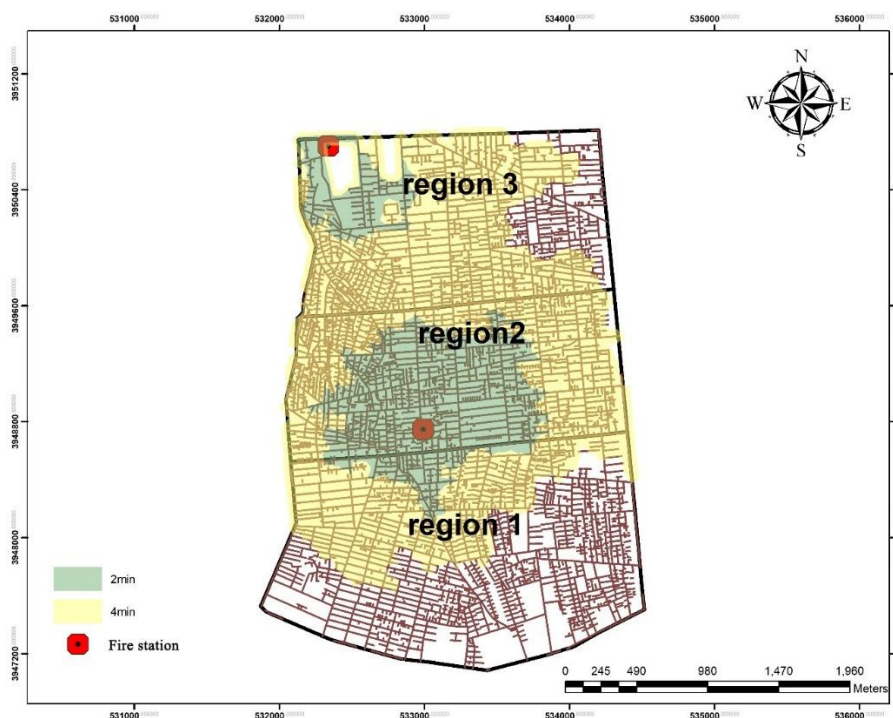


Figure 7 Fire performance level in 2 and 4 minutes.

5.2 Emergency Service Performance Level

According to the standards, the access time of emergency and medical centers in residential areas in the city should be between 4-7 minutes. Emergencies (medical centers) play a significant role in what happens after a crisis occurs when the centralization of hospitals causes limitations in providing medical services to areas far from these centers [38]. The status of the study area in terms of the accessibility of medical centers (hospitals) for the regions of the 10th district of Tehran is shown in Figure 8. Examining this index indicates that the hospitals of this district are located in the third region, and complimentary services cover the northern part of the region; as we go from the northern part of the region to the south of the region, access becomes limited. In such a way that 378 hectares of the entire area are under excellent service level, 228 hectares are under good coverage, and 211 hectares are under poor coverage.

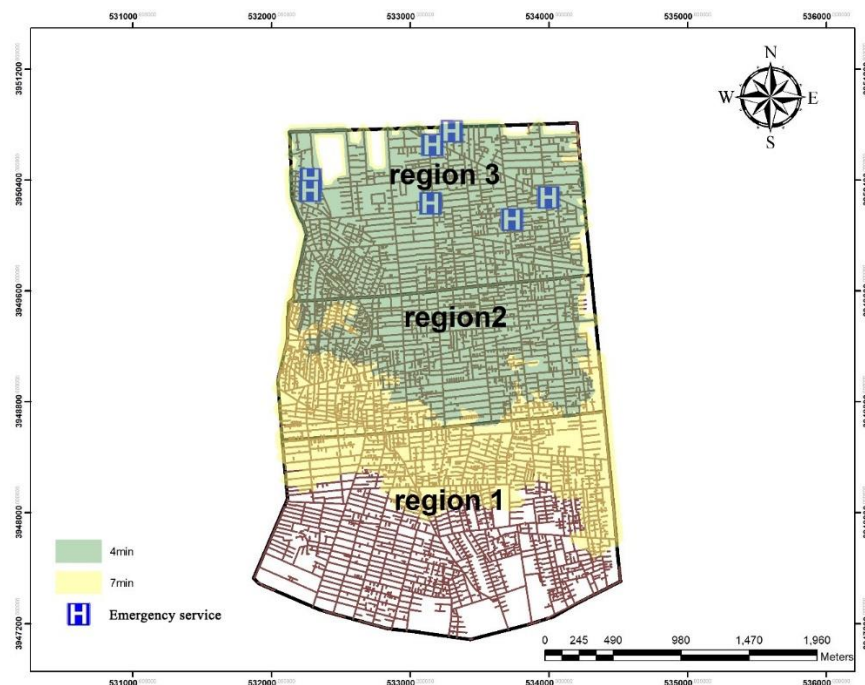


Figure 8 Emergency performance level within 4-7 minutes.

5.3 Crisis Management Centers Performance Level

According to the standard experts, the time interval between crisis management and crisis centers should be between 3-5 minutes. The crisis management center plays a significant role in pre-crisis and post-crisis prevention. Therefore, measures should be taken to minimize damages provide services, and manage incidents. The status of the study area in terms of the accessibility of crisis management centers in the 10th district of Tehran is shown in Figure 9. Examining this index indicates that two crisis management centers are located in regions one and three. The presence of crisis management sheds can always provide services to citizens in times of crisis and reduce vulnerability. The desirability of accessing the crisis management center in District 10. The city of Tehran shows that the southern and northern neighborhoods are covered by the relatively good service of this center, and other neighborhoods of the 10th district of Tehran have limited access. In general, 219 hectares of the entire area are under excellent service level, 417 hectares are under good coverage, and 181 are under poor coverage.

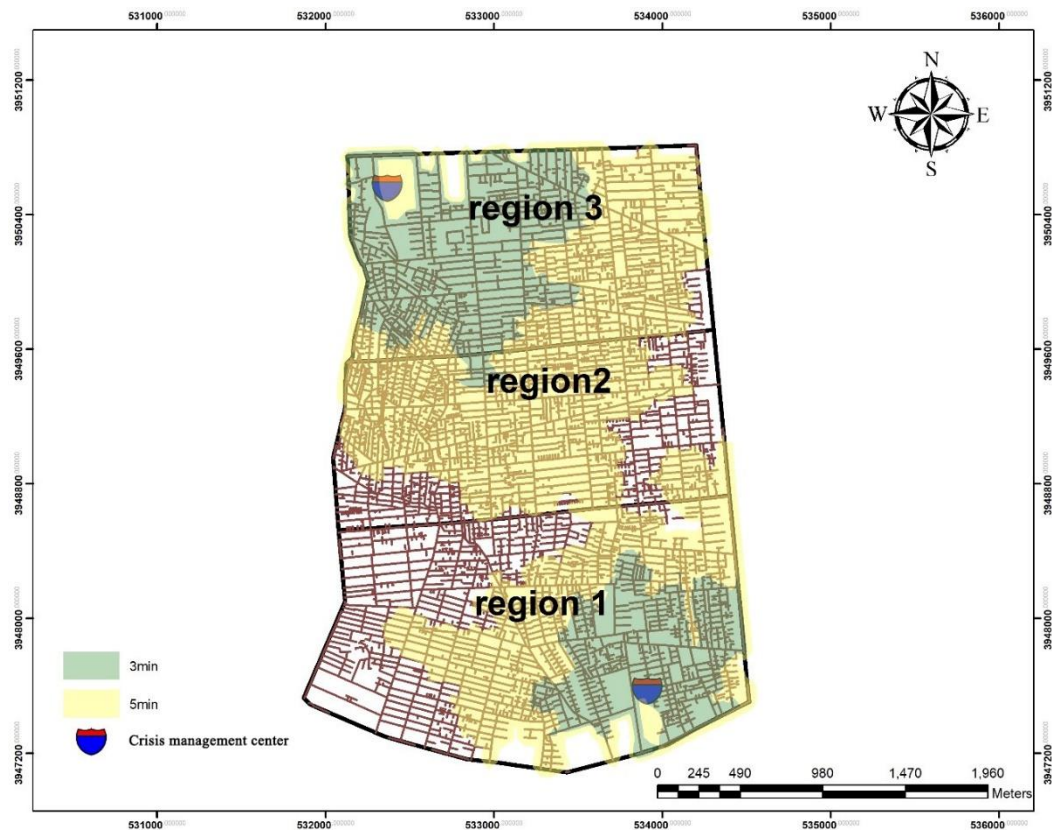


Figure 9 Crisis management performance level within 3-5 minutes.

5.4 Police Performance Level

The status of the study area in terms of access to the police centers of the 10th district of Tehran is shown in Figure 10. This index shows that three police service centers in this district are located in Salsabil, Zanjan, and Haft Chenar neighborhoods. According to interviews with standard experts, the distance between police and crisis centers should be between 5-7 minutes [39]. Examining the access and level of coverage of the police centers indicates that all three neighborhoods located in the 10th region are covered by the optimal service of this type of center. In general, 527 hectares of the entire area are under excellent service level, 285 hectares are under good coverage, and 5 hectares are under poor coverage. A comparison of the level of coverage of vital aid services is shown in Figure 11.

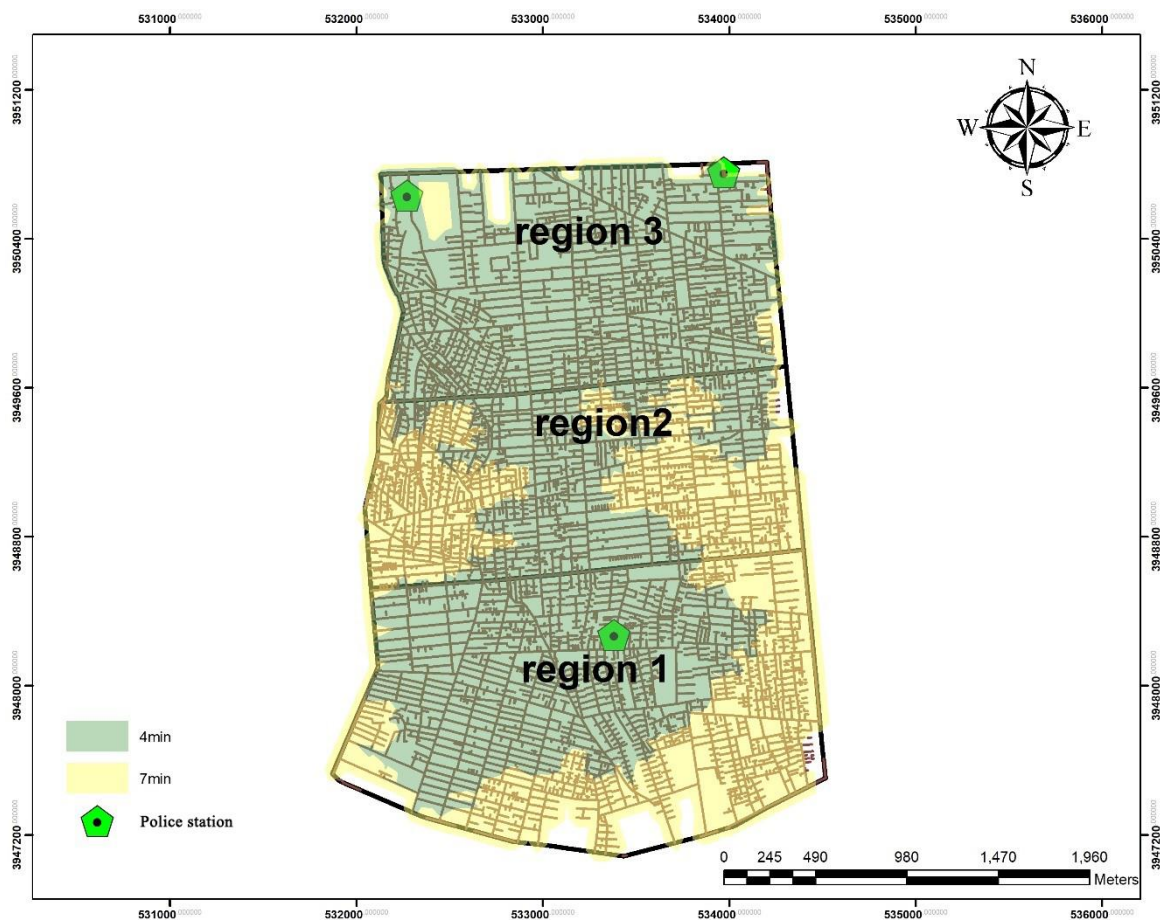


Figure 10 The performance level of the police force in the period of 4-7 minutes.

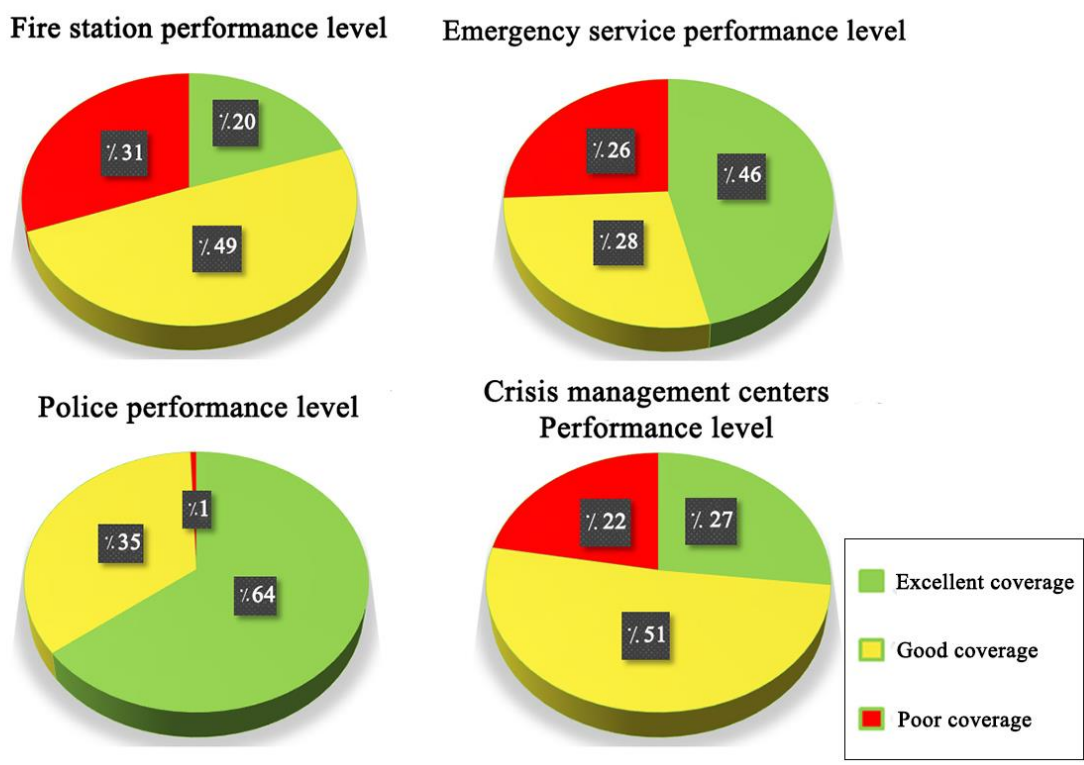


Figure 11 Comparison of the level of coverage of vital aid services.

6. Conclusion

In this research, firstly, the structure of the current situation and the location of critical relief centers such as fire departments, emergency, police force, and crisis management centers were investigated, and the operating radius of these centers was measured according to specific standards. In this research, a Network Analyst was used to analyze 8300 streets in District 10 of Tehran. Each street has been examined by considering the average speed limit, length, and width in the GIS environment to calculate the level of coverage of vital relief services. According to the results obtained from this analysis, the access of fire stations to the southern areas of region one is not in favorable conditions. In general, 162 hectares of the entire region are under excellent service level, 405 hectares are under good coverage, and 250 hectares are under poor coverage. The examination of emergency access in this district indicates that hospitals are located in the third region. Furthermore, the northern part of the region is covered by complimentary services, and access becomes limited as we go from the region's northern part to the south. Investigation of the performance of the crisis management headquarters in the 10th district shows that the southern and northern neighborhoods are covered by the relatively good services of this center, and other neighborhoods in the 10th district of Tehran have limited access. In general, 219 hectares of the entire region are under excellent service level, 417 hectares are under good coverage, and 181 hectares are under poor coverage, and also the investigation of the performance and coverage level of police centers indicates that all three neighborhoods located in the district 10 are covered by the optimal service of this type of centers. In general, in terms of the performance of the service centers in this region, the police force is in better condition. The the crisis management, emergency, and firefighting centers were placed as the following priorities.

According to the obtained results, it is suggested that a new location should be established to create new service centers in areas with weak coverage levels so that the balance in the field of relief is done in the face of future crises. Also, the method used in this research can be used for other cities of developing countries worldwide.

Author Contributions

Faraz Estelaji: Term, Conceptualization, Methodology, Software. Alireza Naseri: Writing - Original Draft, Formal analysis, Validation. Rahim Zahedi: Investigation, Resources, Funding acquisition, Supervision.

Competing Interests

The authors have declared that no competing interests exist.

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