Case Report: Geographic Information System for Timely Search and Rescue Operation: A Case Study in Rigan Earthquake

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ABSTRACT

Background: Short golden time is important to save the injured in earthquake and to start search and rescue (SAR) operation as soon as possible in affected regions. This study evaluated application of geographic information system (GIS) for SAR operation in Rigan Town, Kerman Province, which was hit by an earthquake of 6.3 Richter scale on December 12, 2010 at 22:12.

Materials and Methods: A GIS-based decision-making system with 99 information layers was used to manage the operations in this earthquake. Decisions were made by using available information layers and a proportional scenario. The scenario was designed based on depth and intensity of the earthquake. All residential areas within the radius of 20 km from the epicenter were defined in emergency operation center (EOC) to be considered by SAR teams. Accordingly, SAR teams were called and dispatched to the affected area quickly. They were guiding using radio navigation.

Results: The subsequent assessment on 25, 30, and 40 km buffers showed that there was no need to increase the field of search and rescue. Field managers were supported with provided information about affected people and villages, structural context of buildings, distribution of operational equipments, manpower, resources, and access roads. All of this updated information was provided by designed GIS.

Conclusion: Although the earthquake happened at 22:12 in a rural region with scattered population and 250 km far from decision-making center, the search and rescue operation was completed in the shortest possible time at 2:30 morning, next day.

1. Introduction

Earthquake as a devastating phenomenon is considered costly and dangerous because of its fast, unexpected, and sudden occurrence. Located on Himalaya-Alps earthquake belt, Iran is among the most earthquake-stricken countries of the world [1].

Owing to high occurrence of this phenomenon in Iran, familiarity with its properties and paying attention to its outcomes and implementing comprehensive disaster management programs are crucial. In earthquake disaster management, implementing the programs in the shortest possible time could result in expected outcomes by the programmers [2]. Considering the characteristics of an earthquake such as sudden occurrence which result in a large number of victims and short golden time for rescue, rapid

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intervention plans for search and rescue operation is a must [3].

Although, starting time of search and rescue operation is very important, predicting and applying suitable technologies is very crucial too [4]. Nowadays, GIS applications have been taken into consideration in different areas and disaster management is not an exception. These systems could be applied in all phases of disaster management. Information preparation, as a main element of every operational system, is only a part of capabilities of GIS [5].

This article introduces the results of applying this information system for search and rescue operation in Rigan earthquake. This earthquake measuring 6.3 on the Richter scale struck Rigan Town in Kerman Province at 22:12 on December 12, 2010.

2. Materials and Methods

Such as other phases of disaster management, successful search and rescue operation needs appropriate assessment. Therefore, obtaining enough and necessary information is the first priority. In this regard, compiling and updating information such as recognizing environmental hazards, identifying system vulnerability, determining available resources, and responding to disasters should be done [6].

Having regional risk and vulnerability maps is essential, not only to run preventive programs, but also to do response plans. In most cases, having some information about exact place of schools, dormitories, or crowded places can significantly help the relief and rescue teams [7].

Necessary resources to respond to disasters could also be presented as resource capacity map. These resources include all facilities, necessary equipment, and manpower for response plans and disaster management.

Information of these resources and their locations, as capacity mapping project, could be prepared by various enterprises and organizations. Also patterns, methods, and their results must be shared.

Kerman Province capacity mapping project was performed by Red Crescent Society of Kerman Province in association with Kerman Governor's Office of Disaster Management.

Project objectives were determined based on necessary information to perform a comprehensive disaster management. The lesson learned of Bam earthquake on December 26, 2003 was used in determining these objectives too.

Required information was prepared in the 99 information layers of GIS which could be used in decision making for disaster management. Some samples of these layers were political division, population, number of households, medical centers, search and rescue teams, police posts, airports, road network, railway network, fuel storage and water supply network.

Like other GIS based projects, a variety of reports and outputs could be produced in the form of standard tables and maps on the base of information layers [5]. Figure 1 demonstrates an example.

Case review

An earthquake with moment magnitude 6.3, hit south east Iran at 28.35 degrees north latitude and 59.24 degrees east longitude at 22:12 local time (18:42 GMT) on December 12, 2010. The region was 120 km southeast of Bam in Kerman Province in a widespread rural region which 260 of those villages were inhibited [8].

Emergency operation center (EOC) of Red Crescent Society of Kerman Province was in charge of commanding search and rescue operation. As soon as Geophysics Institute of University of Tehran announced the earthquake, populated areas of affected region were identified using 20-kilometer buffer zone around the epicenter on demographic layers of the system.

The aforementioned areas were defined using related information layers for an imagined scenario of earthquake, proportional to its depth and intensity (Figure 2).

The lesson learned of Bam earthquake on December 26, 2003 was used in defining expected damaged zone. It was shown that the worst damage of Bam earthquake was concentrated within the 16 kilometers radius around the city [9].

The subsequent assessment on 25, 30, and 40 kilometer buffers showed no need to increase the field of search and rescue. Field managers were supported with provided information about affected population and villages, structural context of buildings, distribution of operational equipments, manpower, resources and access roads. All of this updated information was provided by designed GIS.

At the same time, available search and rescue teams were informed, organized and dispatched to the geographic locations of affected people with the quickest access ways for determining and evaluating the status of affected areas.

Having information about affected people, available facilities and resources in places near the earthquake-stricken areas helped managers send the necessary resources as quickly as possible to the field.

In spite of a vast area, difficult geographical and temporal condition, search and rescue teams were managed to determine casualties, triage and transfer the injured people to the nearest medical centers. There was no additional manpower and equipment in the scene.

Although, this operation was performed late at night in a vast area far from command center, search and rescue operation finished at 2:30 AM on December 21, 2010. Also, no rural region was neglected by search and rescue teams.

3. Results

After initial assessment, developing timely and effective life rescue in an integrated disaster management plan is essential to reduce casualties.

Capabilities of the designed GIS-based decision-making system provided the possibility for the EOC to consider all residential areas within the radius of 20 km from the epicenter.

Although the first buffer zone was made on the base of previous experiences [9], the subsequent assessment on 25, 30, and 40 km buffers showed that there was no need to increase the field of search and rescue.

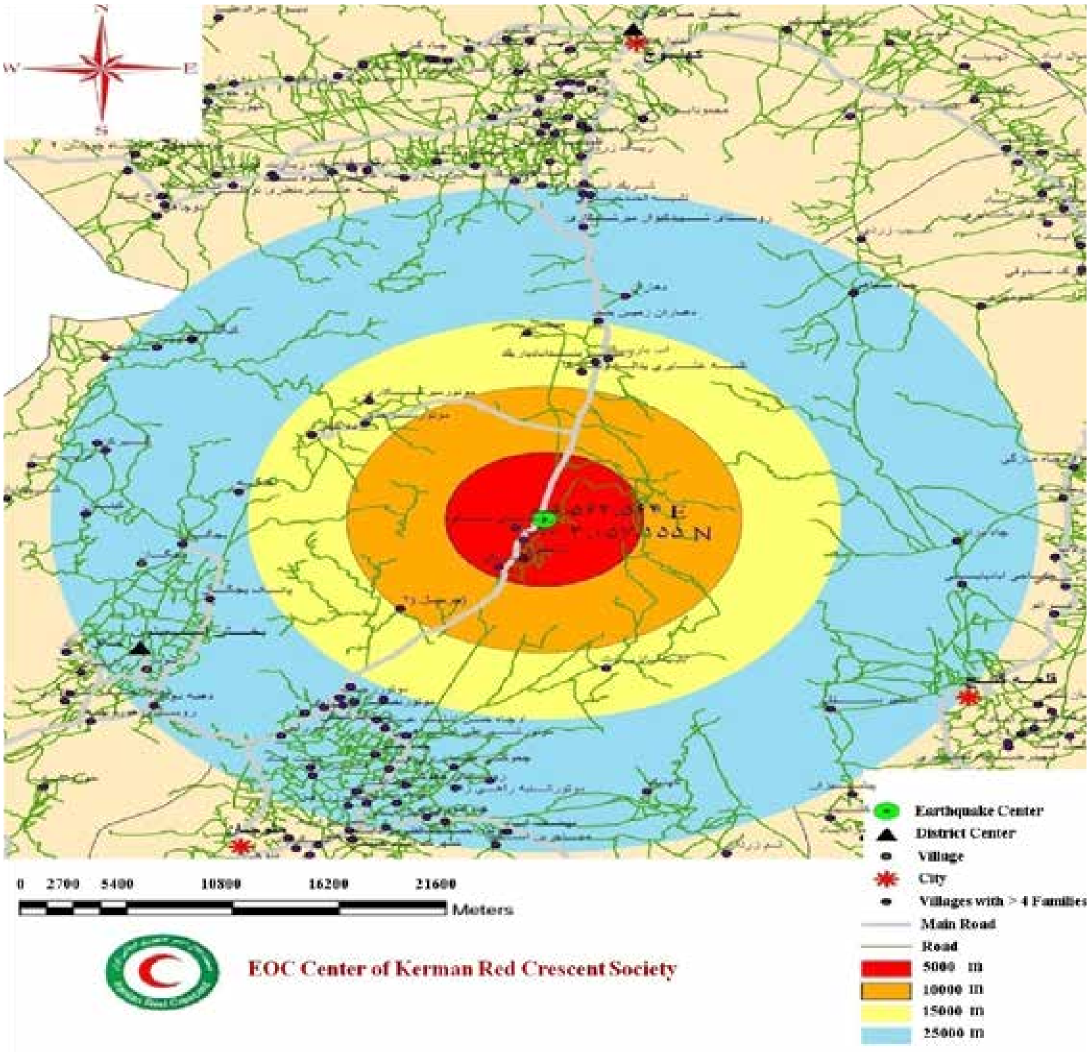

Figure 1. Political division and rural road network in Rigan region.

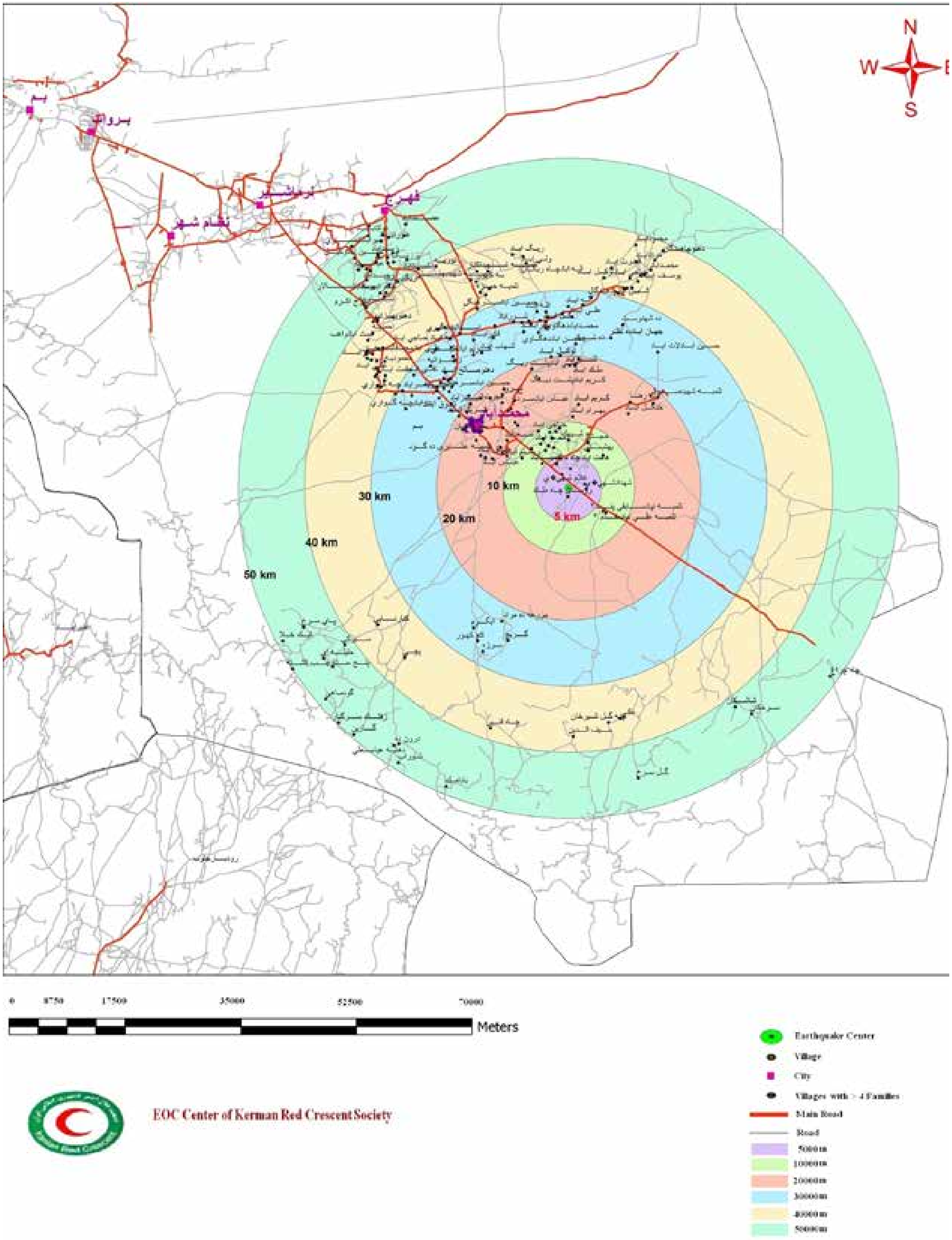

Figure 2. Used buffer zones on demographic layers of the system in Rigan earthquake.

Informing, organizing, dispatching and guiding teams were conducted by the geographical locations and using remote navigation equipment. The mentioned items had an unavoidable role in recognizing the area which was affected by earthquake. They also decreased the time of justifying and dispatching teams significantly, and ultimately the search and rescue was operated as quickly as possible.

4. Discussion

Because of variation in related conditions, there are few reports about comparing the time for rescue operation in destructive earthquakes [10]. To the best of our knowledge, search and rescue was done quicker and more efficient.

Although the first 72 hours after the earthquake is called the golden time for rescue, but more saving in time results in less casualties.

Developing related tools and or models which use all effective factors in evaluating search and rescue time could help managers to critique this process correctly.

Besides having information system, accessing to a safe and efficient data-transfer network in disaster conditions is inevitable. This network with the capability of saving, classifying, and processing data could prepare necessary reports in the forms of maps, graphs, diagrams or tables.

Defining common objectives and unique methods for collecting data and required regulation to oblige all organizations for sharing their existing statistics and information in this network is crucial.

Determined access levels for different organizations in using this network can prevent some problems in response operation, especially the related issues such as "evaluation, search, rescue and relief." This kind of decision-making about access levels should be in charge of national disaster management organization.

5. Conclusion

Sharing information on hazards, vulnerabilities and capacities by specialized organizations and updating this information must also be considered a part of necessities and prerequisites of this program.

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References

[1] Guha-Sapir D, Vos F, Below R, Ponserre S. Annual Disaster Statistical Review 2011: The Numbers and Trends. Brussels: Centre for Research on the Epidemiology of Disasters (CRED); 2012, pp: 1-52.

[2] Rasekh A, Vafaeinezhad AR. Developing a GIS based decision support system for resource allocation in earthquake search and rescue operation. Institute of Cross Cultural Studies and Academic. 2012; 7334:275–285.

[3] Wiley CT. An assessment of geo-information use during the 2005 Kashmir earthquake response and recommendations to improve future use. International Journal of Emergency Management. 2011; 8(1):26-35

[4] Harrison T, Gil-Garcia JR, Pardo TA, Thompson F. Learning about interoperability for emergency response, Geographic information technologies and the world trade center crisis. Paper presented at the 39th Hawaii International Conference on System Sciences (HICCS). Hawaii: Manoa; 2006.

[5] Sreeja SN. Geoinformatics applications in disaster management. New Delhi, India: National institute of disaster management in Ministry of Home Affairs, Government of INDIA; 2012.

[6] Kawamura Y, Dewan A, Veenendaal B, Hayashi M, Shibuya T, Kitahara I, et al. Using GIS to develop a mobile communications network for disaster-damaged areas. International Journal of Digital Earth. 2014; 7(4):279-293.

[7] Zielstra D, Zipf A. A comparative study of proprietary geodata and volunteered geographic information for Germany. Paper presentes at: the 13th AGILE International Conference on geographic information science. Portugal: Guimares; 2010.

[8] Hosseini SK, Sadeghi H. [Preliminary short report of Mohammadabad-e-Rigan, Dec. 20, 2010 Earthquake (Persian)]. Mashhad: SE-Iran Earthquake Research Center, Ferdowsi University of Mashhad; 2010.

[9] Oliviera CS, Roca A, Goula X. Assessing and managing earthquake risk: Geo-scientific and engineering knowledge for earthquake risk mitigation: Developments, Tools, Techniques. Dordrecht: Springer; 2006.

[10] Long ShY, Biin C, Zhong AH. Model design and analog modulation of emergent earthquake rescue system based on CAS Theory [PhD thesis]. Beijing: Chinese Geology University; 2010.