Journal of Yaşar University
http://joy.yasar.edu.tr



# EMERGENCY MANAGEMENT WITH GIS

**Assoc. Prof. Dr. Vahap TECİM[*], Dr. Murat KOMESLİ[**]**

## ABSTRACT

After two big earthquakes in 1999, everybody agreed that Turkey is not well-prepared for any kind of earthquake. Government of Turkey officially did research about the any kind of effects of the mentioned earthquakes, so did many unofficial Turkish and international organizations. Unfortunately, everybody learned that there is no national emergency management system or it is not applicable if there is any.

During the last decade, a number of disasters (national or man-made) occurred throughout the world. North American Tournedos', Japan's Tsunami and earthquakes made people think about what kind of system should be established to prevent countries and people from these kind of disasters. As for Turkey, after the terrible experiences on 17th August 1999 and 12th December 1999, the Governorship of Sakarya had decided to take some precautions.

A special GIS (Geographical Information System) has been developed to hold every kind of important geographical information together with their attributes in the digital environment.

Everybody agreed that there should be specific emergency management system for every part of the world. Governments finally learned that during the disaster -this could be earthquake, flood, tsunami, etc.- it is not possible to manage it remotely (from a distance). Something could be done -especially providing emergency needs and allocating them- immediately in place and in a timely manner.

[*] Dokuz Eylül University Head of GIS Department, The Graduate School of Natural and Applied Sciences
**E-mail:** vahap.tecim@deu.edu.tr
[**] Yaşar University Faculty of Engineering and Architecture, Department of Computer Engineering
**E-mail:** murat.komesli@yasar.edu.tr

**Key Words:** GIS, Emergency Management, Natural Disaster.

## 1. INTRODUCTION

Two important earthquakes, 17 August 1999 Gölcük and 12 December 1999 Düzce, made everybody realise that generally Turkey is not well-prepared for any kind of disaster. It should be noted that the province of Sakarya received the most damage from these earthquakes. They caused the deaths of thousands of people and the economic damage around millions of dollars.

Not many work has been done about emergency management systems especially for earthquake type natural disasters. It should be noted that this kind of academic work cannot be done on the table in the office, since the reality is much more different than theories. Therefore, applicability of any kind of work in this area should be confirmed from different sources of information. To practice the applicability of the deployed system is very important, so that the feedbacks can be received and the weak parts of the system can be re-evaluated and improved.

After the terrible earthquakes, the Governorship of Sakarya had decided to establish a GIS Centre in order to put all the important data into the digital environment. So that it would be much easier to plan and manage many managerial issues. In this GIS Centre, various applications have been developed, such as GIS based city roads update systems, religious information system, land information systems, 3D maps, etc.

The Centre aims to provide all kind of information which is related to the province of Sakarya, to the planners and decision makers. Using GIS as a decision support tool, decision makers can get information about the types of roads (with distance), how many hectares of forest, agricultural land the province has, what quality of land a specific region has, how many schools (with the number of classes, students, teachers, etc.) the province has, etc.

The application of GIS can be extended any spatially related subject since it can be used anything related to the earth. It uses data as a simple map output and analyze data with functions such as overlays in order to produce valuable and understandable information.

## 2.EMERGENCY MANAGEMENT SYSTEMS

Management is not easy, especially when managers work in the uncontrollable area with untrusted/unconfirmed data. Managers normally work under risk. Whoever gives better decision under risk, s/he can be called a successful decision maker. At this point, managers need computer tools providing them with valuable information form raw data in order to reduce the probable future risks as much as possible.

From the above explanation, it is obvious that much more work must be done about the emergency management in advance, so that the important part of the risk can be reduced. By this way, not only the lives can be saved, but also the economic lost can be reduced considerably in case of emergencies.

After realizing that there is no way to stop the disasters, such as earthquake, flood, tsunami, etc., it became necessary to be prepared in advance as much as possible in order to reduce the damage. From this perspective, countries like the United States and Japan have been strongly put in effect the preparations in advance. Every country has its own disaster problem; for example United States mainly has a hurricane problems, and Japan and Turkey mainly have earthquake problems. To reduce the damage of these kind of disasters, every country tries to establish some emergency management plans.

In order to be ready for emergency conditions, special disaster reduction centers and disaster education centers have been built especially in Japan and the US. In the education centers, every kind of educations have been offering to the trainees. These include how to get to the safe place, how to help others, etc. during the earthquake or any other disaster. This kind of information and training are very valueable for the individual readiness.

However, global preparation is more important than individual preparation, since managing the emergency means coordinating the readiness. Deploying the rescue team into the right direction, finding and sending the professional equipment into the places where urgently needed, are the some of the most important activities during the emergency management. In order to do it better, managers need detailed information about the current situation, inventory of the human resources and technical equipments for the whole province.

Governorship of Sakarya established a GIS based Emergency Information System (EIS) especially for crisis management. Figure-1 shows one of the user interface of the system developed in Sakarya. All kind of inventory about Sakarya, vehicles, inventory, qualified and unqualified (mainly technical) personnel, type of factories and their details such as capacities, gas stations, food stocks, electricity lines and transformer, etc. All kind of related data were entered into the GIS and some software have been developed to utilize GIS based data in various ways. During the regular time, EIS helps to provide many socio-economic information to the user. During the emergency time, EIS provides immediate maps and facts about the requested area. Assisting rescue teams, ambulances, fires and polices are very important during the emergency time, and EIS also does that. Where to establish temporary accommodation (tents and prefabricates houses), where to build permanent houses, where are the assembly areas, who will be in charge, what is the evacuation systems, which doctor should go which temporary health unit, how to collect donations, where are the warehouses, etc.

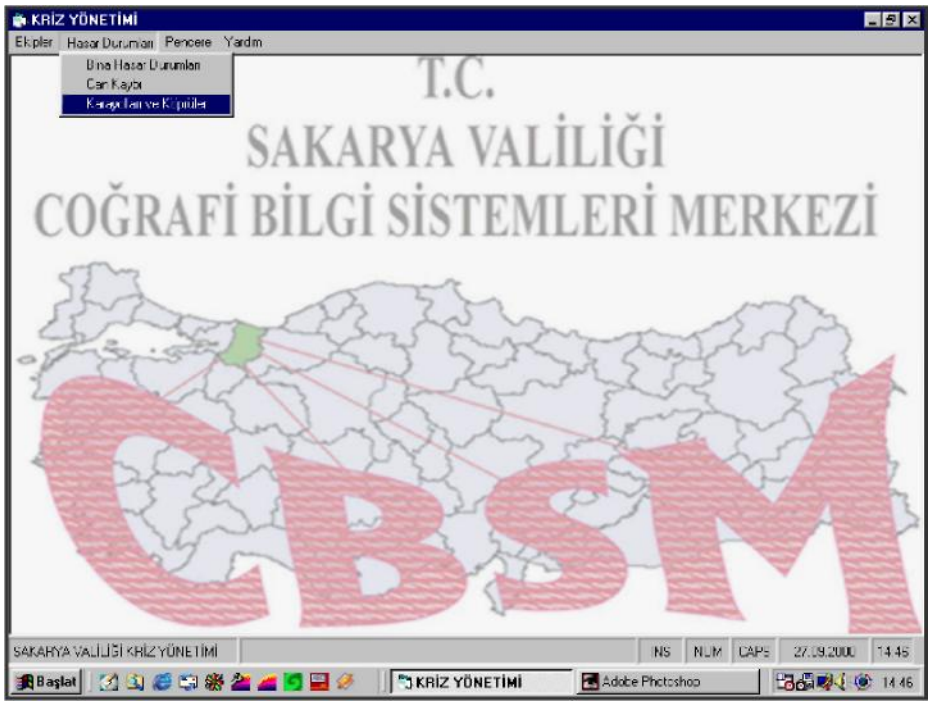


**Figure-1** : GIS developed for Emergency Management for Governorship of Sakarya Province

With the aid of GIS, all of the necessary precautions are handled by the computerized GIS system, especially for planning and management purposes. MapInfo GIS software has been used to develop many applications. The Visual Basic programming language is used for

devel

oping the graphical user interface parts of the GIS.

It should be noted that as a Government Organization, Sakarya is the only one which did every kind of GIS application with their own personnel. The application software was deployed on the Internet environment gradually, so that public can take advantage of maps and map-based applications. Later, the extranet connection with other government organizations had been established in order to share the common map-based information. Internet applications will be improved day by day. Not only vector and raster based maps, but also interactive GIS maps had been deployed into the web site, so that users can utilize some query applications.

## 3. GEOGRAPHIC INFORMATION SYSTEM

GIS can be defined as a set of tools and processes, executed on raw data, to produce information which will be useful in decision making, a chain of steps leads from observation and collection of data through analysis.

GIS is a computer tool, which offers a possibility of handling, processing and analyzing graphic (geographic) and non-graphic (tabular) data simultaneously. As a tool or as an information system, GIS technology has changed the entire approach to spatial data analysis (Clarke, 2003).

GIS aims to help solving problems with a geographical component. The data in GIS may be accessed to obtain answers to questions such as: Where is the best place to do something? What is at location X? What areas are adjacent to route Y? What areas will be affected if I take this action? GIS can provide solutions for these questions. Either private or public organizations regardless of the size of the business, most of the information are geographically referenced. On the other hand, the more information they have, the harder it becomes to manage.

As the examples of GIS usage, the mapping of hazards and risks has since the 1980s been facilitated by the development of GIS. (Hellenberg and Hedin, 2005). It gives a way to highlight the location of a risk in a municipality. For instance, in the present flood mitigation

and prevention the use of GIS and maps are of importance. In Sweden, 50 flood risk maps have been produced in the scale of 1:100.000. They are available as GIS data files and the public can study an overview of them. (Hedin et.al. 2006)

GIS uses geographically referenced data as well as non-spatial data and includes operations which support spatial analysis. It should be noted that in GIS, common purpose is decision making, for managing use of land, resources, transportation, retailing, oceans or any spatially distributed entities. (Tecim, 2001)

As illustrated in Figure-2, GIS is a system of hardware, software, people and methods designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for solving complex planning and management problems (Yomralıoğlu, 2005). GIS also performs spatial operations.

GIS involves different subjects, such as cartography, remote sensing, photogrametry, surveying, geodesy, statistics, operations research, computer science and mathematics.

### 3.1. The Use of GIS as Decision Support System

GIS and Decision Support Systems (DSS) are mechanisms that can be used to provide managers with information needed to make sound resource management decisions. The role of the probable GIS/DSS committee in the governorships is to examine the use of geospatial data, technologies, and analyses within the city and assist the other committees with implementing this technology to effectively manage the resources.

Cowen (1988) examined the alternative definitions of the dynamic field of GIS, and tried to distinguish GIS from other forms of automated digital analysis. He suggested that a GIS is best defined as a decision support system involving the integration of spatially referenced data in a problem solving environment. It provides the tools, particularly polygon overlay, that the users have always required to integrate various sources of spatial information. (Cowen, 1988)

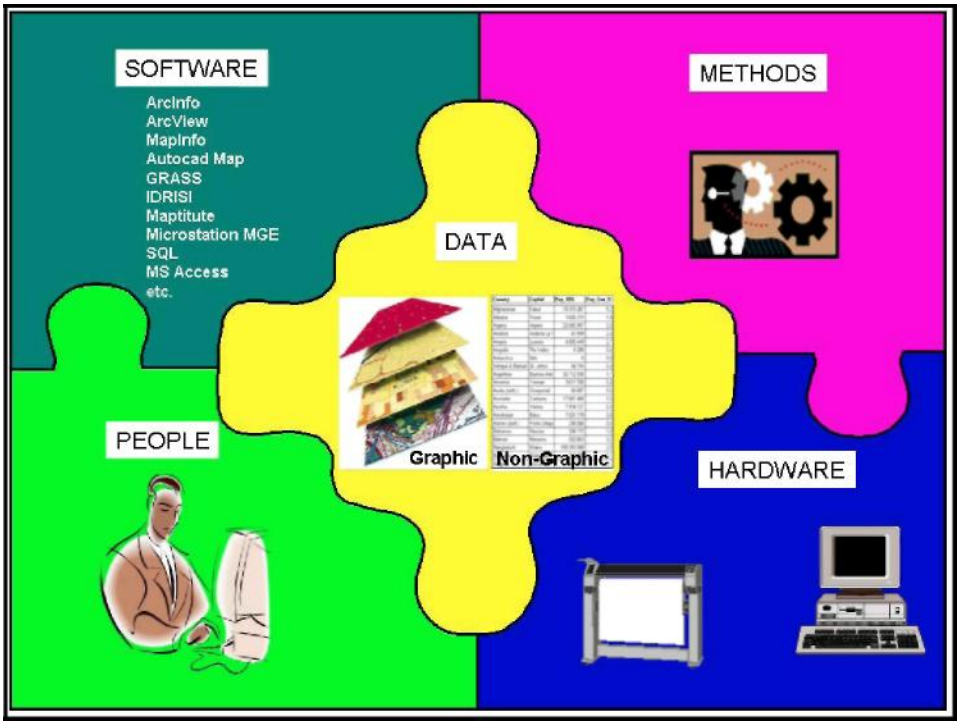


**Figure-2 :** Geographical Information System and it's components.

## 4. PROPOSED ARCHITECTURE FOR EMERGENCY MANAGEMENT WITH GIS

Emergency management is an important and necessary process for every sensetive and responsible organization. Depends on the interested area, governments are focused on wide range of problems. On the other hand, private organizations may be interested in very specific case.

As mentioned earlier, this article focuses on local government cases, and proposes an architecture how to deal with managerial issues during the disaster. To deal with disaster, any government needs specific plans and management system for any situation. Otherwise, experiences showed that the loss of death and economy are so big that there is no way to recover them.

For many years, governments are faced with disaster problems. For the last ten years, map-based computer technology developed variety of advanced strategies for governments while dealing with disasters. GIS technology allows users to create complex maps and sophisticated new maps are being developed that are based not only on street addresses, but also on coordinates. The maps could speed rescues and general responses to disasters like

Hurricane Katrina. In developing countries, Emergency Management agencies specializes in Hazard Mitigation, Warning & Communications, Emergency Police Services, Disaster Response & Recovery, Hazardous Materials & EPCRA, Radiological Emergency Preparedness, and Exercise & Training for the specific area (Emergencymanagement, 2008).

Figure-3 shows that how GIS based Emergency Mangement System (EMS) could be used before and after the disaster. It should be noted that, well-prepared (well organized) local government will have a big advantage to deal with disaster or emergency situation.

The Government should have a big spatial and non-spatial database about its responsible areas. Collecting the correct data from the original sources, will give important advantage to the EMS when it needs to work. As seen in Figure-3, before the disaster EMS helps organization to prepare the responsible area for any kind of emergency situation. At first, EMS will help for precaution, then reduce damage and later preperation. All the information about vehicles and their drivers is already stored in the EMS database. During the emergency situation only rescue team works to save lives.

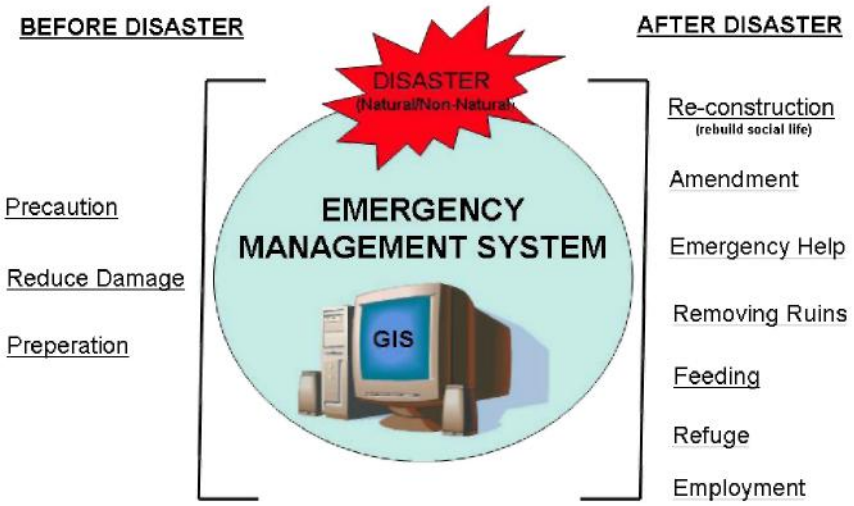


**Figure-3**: Functions of Emergency Mangement System.

But the most important thing is 48 hours (mainly 72 hours) after the disaster. GIS

based EMS provides valuable information of recovery plan which listed right side of Figure-3. Every map information is very important to solve the correct problem at specific time. Organizing an area from rescue to the reconstruction process, EMS will give valuable assistance.

Figure-4 shows the data collection and manupilation of GIS part of the EMS. The most important issue in GIS based project is to collect correct coordinated data from the sources. While GIS can use spatial and non spatial (attribute) data, it can create all kind of thematic maps for EMS to use emergency cases.

During the emergency situation, all the necessary information provided by the developed software, as a local government, what to do, how to do, where to go, how to allocate police, health, rescue teams, etc. The city's inventory must be created and put into the database system. To create a big scale street maps are important to dealing with the emergency situation.

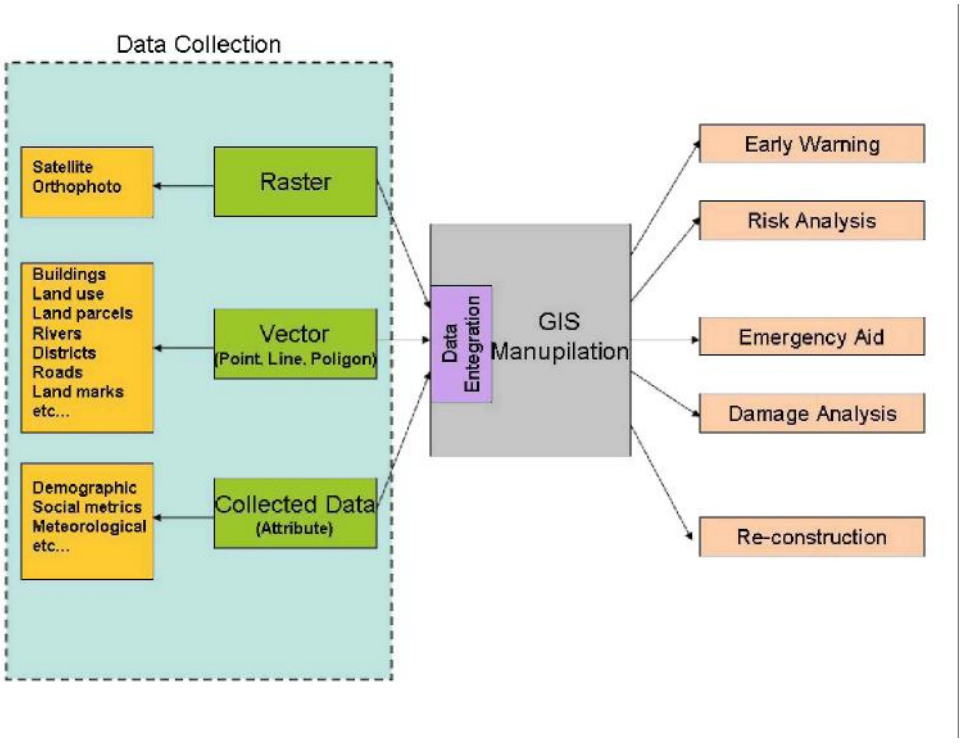


**Figure-4:** Data Collection and Manipulation of GIS for Emergency Management System.

All kind of inventory about the city, vehicles, inventory, qualified and unqualified

(mainly technical) personnel, type of factories and their details such as capacities, gas stations, food stocks, electricity lines and transformers, etc. must be collected. All kind or related data are entered to GIS systems and several software have been developed to use GIS based data in various ways. During the regular time, EMS helps to provide many socio-economic information to the user. During the emergency time, EMS provides immediate maps and facts about the certain area. Assisting rescue teams, ambulances, fires and polices are very important during the emergency time, and EMS will undergo all of those issues. Where to establish temporary accommodation (tents and prefabricates houses), where to build permanent houses, where are the collection points, who will be in charge, what is the evacuation systems, which doctor should go which temporary health unit, how to collect donations, where are the warehouses for clothes, equipments and heavy vehicles, etc. With the aid of GIS, everything is handled by computer, especially for planning and management purposes.

Figure-4 demonstrates the basic data collection and manipulation process. With the capability of GIS, many special map-based results will help different organizations and teams to do their job better during the emergency situation.

## 5. CONCLUSSIONS AND FUTURE WORK

Within this study, architecture for Emergency Management System by utilizing GIS techniques has been proposed. The aim is to minimize the chaoses during and after the emergency cases. The detailed information and explanations are provided in order to be ready before an emergency situation. It is clear that GIS with digital map overlays can be best utilized as an Emergency Management System.

As a future work, the integration of GIS with other systems already deployed in an organization such as Governorships becomes an important research and application area. The future use of Semantic Web techniques on the forementioned integration process has the potential to aid planners and decision makers in variety of areas. Ontology based applications (Gruber, 1993 and Fonseca, 2002) and especially semantic web are very important for the use of different purpose GISs.

**REFERENCES**

CLARKE, K.C., (2003) Getting Started with Geographic Information Systems, Prentice Hall, New Jersey.

COWEN D.J., (1988) *GIS versus CAD versus DBMS: What are the Differences?* Photogrametric Engineering and Remote Sensing, Vol.54, No.11, pp 1551-1555.

EMERGENCYMANAGEMENT (2008) Emergency Management Web Site http://emergencymanagement.wi.gov/, date 20/02/2008.

FONSECA, F. T.; Egenhofer, M. J., Agouris, P. Câmara, G., (2002), *Using Ontologies for Integrated Geographic Information Systems*, Transactions in GIS, Jun, Vol. 6 Issue 3, p.27-30.

GRUBER, T., (1993), *Toward Principles for the Design of Ontologies Used for Knowledge Sharing*, International Journal of Human and Computer Studies, 43(5/6): 907-928.

HEDIN, HELLENBERG, PURSIAINEN (2006), The Eurobaltic I (2003-2006) Project on Civil Protection in the Baltic Sea Region: Best Practices and Lessons Learned.

HELLENBERG T. and HEDIN S. (2005), *Risk assessment and mapping.* Safety Dimensions of Spatial and Physical Planning. p.p.8

TECİM, V., (2001), *Coğrafi Bilgi Sistemleri: Temel Kavramlar, Uygulama Alanları,* s.66.

YOMRALIOĞLU, T., (2005), Coğrafi Bilgi Sistemleri: Temel Kavramlar ve Uygulamalar, 3.Baskı, Akademi Kitapevi, Trabzon.