GIS-AIDED EMERGENCY MANAGEMENT ACTIVITIES IN THE WORLD AND TURKEY: A CURRENT LANDSCAPE

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Abstract

The event of September 11, Hurricane Katrina, and major earthquakes in the world have shown the importance of the GIS-aided emergency management activities. Emergencies, from hurricanes to wildfires, each can be deadly; hovewer, preparation and good planning may reduce their damages. GIS-aided tools are becoming an important part of the emergency management activities today. Researchers are developing new aspects for dealing with emergencies by using computer and communication technologies. They are also using analysis and modeling techniques such as operations research, risk analysis, simulation, spatial decision support systems (SDSS), artificial intelligence-expert systems, and geographic information systems (GIS) to manage emergencies via developing new approaches. Emergency management needs accurate and quick information for dealing with a disaster in a timely and safe manner. Because all phases in emergency management are graphically and spatially related to each other, GIS and their tools have a greater role in these activities. In this study, emergency management phases and activities and the importance of the GIS and their related tools such as spatial decision support systems are taken into consideration. Moreover, current information about GIS-aided emergency management activities in the world such as CEMPS, GIERS, REMS, OREMS, FEMIS, etc. are given in this context. After the two devastating earthquakes in the Marmara Region of Turkey in August and September of 1999, several emergency management agencies have been established and several activities have been carried out. TABIS (Turkish Disaster Information Systems), ISTABIS (Istanbul Disaster Information Systems), and HAZTURK can be included in emergency management acitivities in Turkey and in this paper, detailed information are given about them.

Introduction

The event of September 11, Hurricane Katrina, and major earthquakes in the world have shown the importance of the GIS-aided emergency management activities. Emergencies, from hurricanes to wildfires, each can be deadly; hovewer, preparation and good planning may reduce their damages. One of the specific difficulties in responding to such disasters is lack of response coordination. Another difficulty is delivery of the goods to incident areas. These

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difficulties may be overcome by using integrated information and communication systems, geospatial data and tools, and GIS-aided spatial decision support systems.

GIS-aided tools are becoming an important part of the emergency management activities today. Researchers are developing new aspects for dealing with emergencies by using computer and communication technologies. They are also using analysis and modeling techniques such as operations research, risk analysis, simulation, spatial decision support systems (SDSS), artificial intelligence-expert systems, and geographic information systems (GIS) to manage emergencies via developing new approaches (Tufekci and Wallace, 1998).

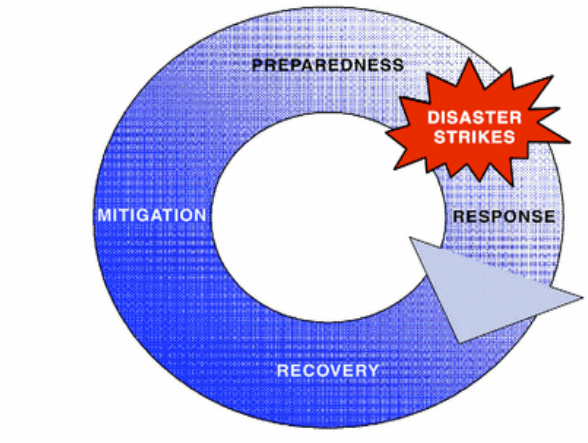
A GIS, which is one of the geospatial tools, can be used for consequence assessment and developing a disaster response plan by integrating data such as school locations, neighborhoods, key infrastructures, and disaster personnel. GIS can help disaster responders for different scenarios and types of events and create the action plans in deploying the disaster personnel. GIS and its extensions can also help manage data in real-time, allowing disaster managers to make important and proper decisions. GIS also facilitates all of the requirements of disaster planning procedure by allowing decision makers to view appropriate combinations of spatial data (ESRI, 2001).

The widespread integration with geo-spatial technologies and emergency management provides opportunities for large-scale, automated, comprehensive collection of data about operations, decision making, and situational knowledge throughout a disaster. This information can be processed in order to improve understanding of the process of emergency management. Geo-spatial technologies can also help to make these lessons learned available in real time, putting them into the hands of decision makers when they are most needed.

The Spectrum of Emergency Management

US National Governor's Association developed an all-hazard or comprehensive emergency management model in the early 1970s. With this approach, emergency management activities divided into four functional classes: mitigation, preparedness, response, and recovery (See in Figure 1.). While mitigation and preparedness are pre-emergency activities, response and recovery are considered during and post-emergency activities, respectively. Mitigation deals with emergencies to prevent or reduce losses. Preparedness is planning and enhancing response activities in an emergency. Response begins immediately following an event and examples include mass evacuation, providing medical care, search and rescue, firefighting, containing the hazard, and protecting property and the environment. Recovery continues after the event to restore lifelines (Waugh, 2000).

Figure 1. Emergency Management Life Cycle (NRC, 2007)



Use of Geospatial Tools in Emergency Management

Geospatial tools have a great potential in emergency management life cycle for saving lives, limiting damages, and reducing the costs. Emergency managers, especially, would like to know where the incidents are, where their impacts are greatest, where critical information is needed to respond. Because of the chaotic nature of emergencies, emergency managers need geospatial data and tools that are collected and distributed in the form of useful products to allow effective response without any confusion.

The term of geospatial includes interdependent resources such as maps, data sets, tools, and procedures. Geospatial tools can consist of several forms including paper maps, in-car navigation systems, internet sites, software and databases; and analytical, mapping, and visualization tools that support decision-making in emergency management. Remote sensing, Geographic Information Systems (GIS), Computer-Aided Design (CAD), Spatial Decision Support Systems (SDSS); and clearinghouses, geolibraries, archives, geoportals, and geobrowsers can be taken into consideration as types of geospatial tools in emergency management activities (NRC, 2007).

GIS are able to integrate information from different sources, scales, accuracies, and formats into a single source; and they could facilitate modeling, mapping and spatial decision support. These systems can be used for training in the preparedness phase, or in responding to actual emergencies. Recent developments in real-time GIS, remote sensing, interoperable GIS, and the Internet have greatly influenced emergency management activities (Cova, 1999).

GIS can be a powerful tool for analysis purposes because each phase in the emergency management life cycle is geographically and spatially related to each other. According to Thomas et al (2003), geo-technologies are at the center of the emergency management life cycle and GIS support the decision-making process by providing people with a tool for assessing and analysing the geographic nature.

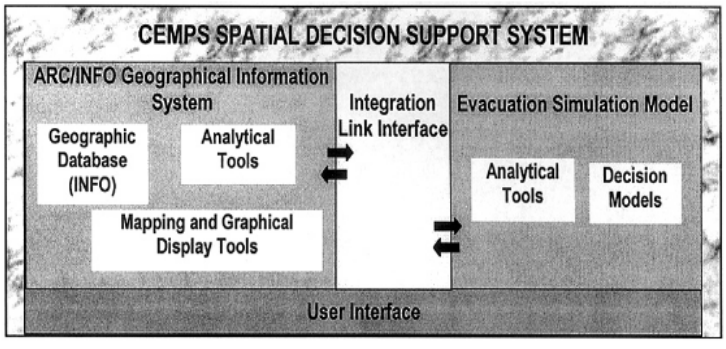
Current Landscape in The World

In this section brief information are given about current applications in GIS-aided emergency management activities in the world.

CEMPS (Configurable Emergency Management And Planning Simulator)

GIS-based emergency management system is **C**onfigurable **E**mergency **M**anagement and **P**lanning **S**imulator (CEMPS) which is designed for contingency planning in emergency evacuation (See in Figure 2). CEMPS contains four main components which are a generic object oriented evacuation simulation model, a GIS component, an integration link interface, and a user interface (Silva and Eglese, 2000):

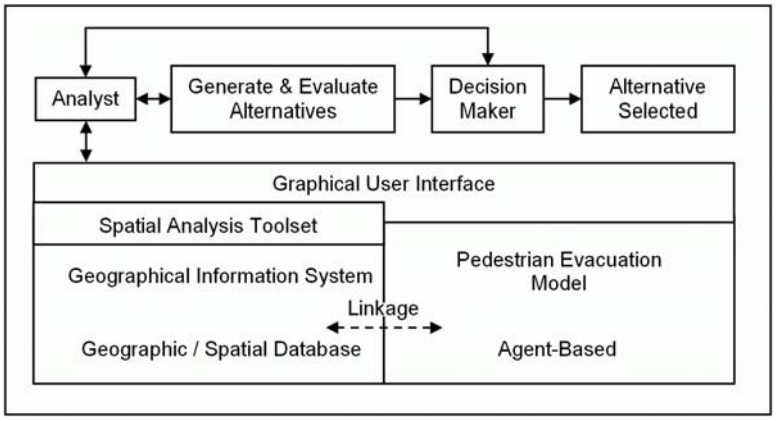
Figure 2. Overview of the CEMPS spatial decision support system (Silva and Eglese, 2000)



KXSDSSES (King's Cross Spatial Decision Support System for Emergency Services)

Similar with CEMPS, KXSDSSES provide the designation of contingency planning before an emergency evacuation rather than real-time emergency management use. According to Castle and Longley (2005) the objective of the study is to create a prototype of KXSDSSES to evaluate and contribute to emergency services to be prepared for a major disaster within the London King's Cross redevelopment. A schematic representation of KXSDSSES can be seen in Figure 3. In this structure, the analyst and/or decision-maker interacts with the system via a graphical user interface.

Figure 3. Schematic Representation of KXSDSSES (Castle, 2006)



HURREVAC (HURRicane EVACuation)

Another GIS-aided emergency management system is HURREVAC which stands for "Hurricane Evacuation" and is a restricted-use computer program funded by FEMA and USACE for emergency managers tracking hurricane route and assisting the evacuation decision-making for managers (Sea Island Software Inc, 2007). The real-time data analysis tools allow the managers to make exact decisions based on FEMA Hurricane Evacuation Studies and distributed real-time forecast data.

More GIS-Aided Emergency Management Applications in the World

In addition to above developments, there are numerous applications related to emergency management and GIS-aided decision support systems. One example is REMS (**R**egional **E**vacuation **M**anagement **S**ystem) which was developed at the University of Florida for hurricane evacuation modeling. This system has simulation-based environment based on several network optimization models in estimating the evacuation time and the traffic flow on a given transportation road network (Tufekci, 1995).

Another example is **O**ak **R**idge **E**vacuation **M**odeling **S**ystem (OREMS) which is mainly developed at Oak Ridge National Laboratory (ORNL) for simulation of traffic flow during an emergency evacuation (Franzese and Sorensen, 2004).

Automation can help disaster managers in succesfully responding to the disasters under the pressure of time, risk, and inadequate information. The **F**ederal **E**mergency **M**anagement **I**nformation **S**ystems (FEMIS), developed at the Pacific Nortwest National Laboratory (PNNL), USA, is an automated decision support system that integrates all phases of disaster management (FEMIS, 2007).

An additional GIS-aided emergency management system is RODOS (**R**eal-time **O**n-line **D**eci**O**n **S**upport) system which was developed for european countries after the Chernobyl accident on 26 April 1986. The system is effective before, during, and after an emergency and it can be used in a broad range of emergency activities such as sheltering and evacuating

people, distribution of goods, agricultural countermeasures, relocation, decontamination, restoration, etc (RODOS, 2005).

In addition to these developments, **R**eal-time **E**mergency **A**ction **C**oordination **T**ool (REACT) which was developed from NVision can be used as a GIS-aided emergency management system with various real-time models. It helps first-responders visualize and determine the impact of a disaster as well as helps the decision-makers by monitoring the situation environment and resources available (NVision Inc., 2005).

Attacks on the World Trade Center show the importance of quick emergency response in urban areas and multi-story buildings, which resulted in structural damage. With this goal, Kwan and Lee (2005) examine the opportunities of using 3-D GIS for the development and implementation of **G**IS-based **I**ntelligent **E**mergency **R**esponse **S**ystems (GIERS) helping quick emergency response to attacks on multi-level structures.

Emergency management planning tools also play an important role in emergency response. These tools allow evaluation of alternative ways to respond to an emergency. They may be used for estimation of emergency event impact and include capability of emergency impact modeling tools. For instance, an online tool which is developed by Innovative GIS/Berry and Associates//Spatial Information systems (BASIS) can be used for forest fire response planning (Innovative GIS, 2003).

Current Landscape in Turkey

After the two devastating earthquakes in the Marmara Region of Turkey in August and September of 1999, several emergency management agencies have been established and several activities have been carried out. In Turkey, especially, very few studies on data collection have been accomplished. For this reason, the input data quality are not enough to get the desired output information from disaster management life cycle. Another issue is the disconnected studies for these kinds of activities. For example, in Istanbul many studies have been initiated on emergency management. However, the completed ones are not able to work together or use each others data. This inharmoniousness also affects those systems and the decision makers who use those systems (Sahin et al, 2006).

Development of The GIS Standards For Turkey Disaster Information System (TABIS)

The high probability of Istanbul Earthquake has initiated important agreements about disaster management activities between Turkey and United States of America. Turkey Disaster Information System (TABIS) is one of the projects signed between ITU and Ministry of Interior of Turkey. The exact name of this project is "Development of a National Database Using GIS and Remote Sensing System and Standards for a Disaster Management Decision Support System" (Karaman and Sahin, 2004).

The base of the Turkey Disaster Information System is Basic Spatial Database. The reference model of the TABIS system comes into existence from two vectoral components. These components are (Karaman and Sahin, 2005);

- Digital Spatial Model (SMM) and
- Digital Disaster Model (SAFM)

Both digital models form the space by separating it to its components based on object oriented basis. This process is called as atomizing of the space in the database modeling. The atomized data of the both digital models prepared as an object catalog. These catalogs are (Karaman and Sahin, 2005);

- TABIS-Basic Topographic-Spatial Object Domains Catalog (TABIS-TOK)
- TABIS-Disaster Management Object Domains Catalog (TABIS-AOK)

The aims of the TABIS-TOK and TABIS-AOK are the modeling of the concrete objects which are the characteristic parts of the topography and emergency management domains of the region where the system will be constructed.

ISTABIS Project (Istanbul Disaster Information System Project)

ISTABIS is the application of the TABIS for the city of Istanbul in the selected region. The system will provide the user association to reach the current, correct, and consistent data. The aim of the project is to create an information system which has the capability to help the decision makers, ministries, governments and municipalities to conduct the planning, mitigation, response and recovery phases of the emergency management, by using modern satellite techniques and information systems, before, during and after the disaster occurs (Şahin et al, 2006).

In the Project, the completed tasks so far are the infrastructure such as servers and computers, determination of the spatial data, sources, formats, and references, designation of the system proposed, acquisition of the spatial and non-spatial data for pilot region selected, process of database design, analysis and comparision of database models. The next task of the project is to create analysis tools to help decision makers taking into consideration the disaster plans of the Governorship of Istanbul. With the help of the study, a comprehensive information model will be presented and authorities will be supported on their decisions by improving the TABIS standards. Thus, the system will be used as a decision support system by evaluating the different scenarios in efficient manner. In this case, the expected Istanbul earthquake will be better targeted and managed, and additional lives may be saved.

HAZTURK (Hazards Turkey- Development of an Earthquake Loss Estimation Tool for Turkey)

The other emergency management activity for Turkey is to design HAZTURK (Hazards Turkey) program nationwide to mitigate the long term effects of the natural disasters on human life at social and economic areas. The designing HAZTURK program will help on natural risk management, program development, development of the current lifelines of Turkey according to the seismic hazards, and designing more stable economy in addition to development and testing of methods for hazard characterization.

The key objectives for the HAZTURK are to:

- Develop an earthquake hazard characterization model for Turkey based on HAZUS.
- Create a comprehensive Turkish inventory database for loss estimation.
- Develop vulnerability functions for infrastructure at risk to supplement those in HAZUS.
- Develop parameters for casualties, shelter needs and economic loss that reflect conditions in Turkey.
- Provide improved near real time loss assessment capability based on Turkish information resources.
- Provide software that takes full advantage of state-of-the-art GIS platforms and internet capability.
- Provide user-friendly computer interface and support materials suitable for a wide variety of users in Turkey including emergency managers, scientific investigators and decision makers (Şahin and Karaman, 2006).

More Applications in Emergency Management in Turkey

Another project based on TABIS is Rize ABMES-KBS which is “Installation of Disaster Management and Meteorological Early Warning System in Rize Province and Urban Information System” in Rize City in Turkey. In this study, a new system will be established using Geographic information systems, remote sensing and meteorological early warning

system in order to minimize the impact, loss of life, and loss of property against the disasters that will affect Rize city and provincial area. With the realization of the study, a system which can be used for disaster management, loss estimation and planning and application of emergency response will be available. Also, a decision-support system functioning for governmental and local authorities will be ready (Sahin et al, 2006).

There are some projects about GIS-based seismic risk mitigation in Turkey. One of these projects is ISMEP which is "Istanbul Seismic Risk Mitigation & Emergency Preparedness Project". The specific objective of the project is to improve the city of Istanbul's preparedness for a potential earthquake through enhancing the institutional and technical capacity for disaster management and emergency response, strengthening critical public facilities for earthquake resistance, and supporting measures for better enforcement of building codes and land use plans (Sahin, 2006).

The other project is "The Study on a Emergency Prevention/Mitigation Basic Plan in Istanbul Including Seismic Microzonation in the Republic of Turkey". In the main report of this project, existing social and physical conditions of the study area are described and seismic damage analysis was carried out based on the potential big earthquakes. Necessary recommendations for the seismic disaster prevention and mitigation were also made. The Study Team developed a comprehensive geographic database (GIS) to support data analysis and presentation of the study results. "Microzoning Maps" were compiled out of this GIS database in such a way that those who are interested in urban analyses, detailed emergency management, studies and planning for Istanbul area may easily make use of the database (JICA and IMM, 2002).

There is also one more project related to e-government and emergency management in Turkey. This project is "System Design of Disaster Management Information System in Turkey as a Part of e-Government". The consultancy of this project has been given to Yıldız Technical University in Istanbul. The Disaster Information Management System (AFAYBIS) which based on GIS consists of two components namely data and process design and communication design (Eraslan et al, 2004).

Conclusion

In this paper, emergency management phases and activities and recent projects in the world and Turkey are taken into consideration. GIS-based tools play an important role in emergency management. Emergency management needs accurate and quick information for dealing with a emergency in a timely and safe manner. Because all phases in emergency management are graphically and spatially related to each other, geospatial tools and effective GIS-aided emergency management have a greater role in these activities.

Confronted with new reality, researchers and practitioners should be aware of rethinking the role of geospatial technologies in emergency management. The design, development, use, and evaluation of disaster management information systems clearly needed to take a far more prominent place on the agenda of researchers, emergency managers, and policy makers worldwide.

In the World there are numerous geospatial based applications to deal with emergencies at local, regional or global level. The countries including developing World such as Turkey are trying to become an Information Society member and trying to use geospatial information for decision making process in effective emergency management. Especially, GIS activities have intensively been performed during and just after Kocaeli Earthquake (Comfort, 2000). However there are still many challenges to overcome in terms of dealing with emergencies in efficient manner in Turkey.

The experiences of recent emergencies have shown that the GIS-based tools are extremely important means that must be integrated effectively into emergency planning and management activities. Emergency management personnel must practice the use of geospatial

data and tools under a range of scenarios and must be fully familiar with the kinds of problems they can confront. In this case, emergencies will be better targeted and managed, and additional lives may be saved.

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