Using GIS in Natural Disaster Management

Natural disasters are sudden unexpected events that cause environmental, financial and human loss. These events include avalanches, blizzards, drought, earthquakes, extreme heat or cold, hurricanes, landslides, tornadoes, volcano eruptions, and wildfires. Their detrimental effects can be thwarted or minimized if the public is sufficiently prepared. Geographic Information Systems (GIS) offer valuable spatial data to emergency management response units during and following natural disasters.

GIS is a valuable tool in addressing natural disaster management processes. The program is designed to provide succinct, up-to-date information particularly to managers and first responders in their assessment of the natural disaster, at any stage. Emergency response professionals can combine road, population and land data into a clear map format prior to a natural disaster. The events may be natural but rebuilding after the wake of destruction becomes the responsibility of the victims. GIS can alleviate some of the surprise and fear associated with sudden natural disasters by combining today’s technology with emergency management knowledge. Since there are often several agencies or organizations working together during emergencies, using GIS allows trained responders to quickly upload and share information between command centers across town or across the world. When a disaster hits, time means lives. Having access to valuable information instantly is what will provide the basis for future GIS processes.

Emergency management has three main objectives “protecting life, property and the environment” (Johnson, 2000). GIS can be an invaluable resource in meeting these requirements through the emergency management cycle that includes planning, mitigation, preparedness, response and recovery stages. Each of the phases overlap one another and using GIS, prior to a natural disaster, to analyze spatial data creates a broad framework for emergency managers.

In the planning stage, GIS can be used to identify future hazards in the event of a natural disaster such as a potential flood zone. With this information, the rest of the emergency planning process can begin to solidify. Areas that are highly vulnerable during an emergency can be identified through GIS data and proper mitigation proceedings can take place to ensure safety.

Mitigation refers to the phase when actions are taken to avoid or reduce the likelihood of a natural disaster. This may include implementing management plans in vulnerable areas, such as building restrictions in areas prone to floods. Locations that are particularly susceptible to natural disasters may execute more comprehensive plans to avoid detrimental effects from unavoidable events.

Preparation is a vital part of emergency management; GIS can provide information that is valuable during real emergencies. Several “what if?” questions can be answered through preparedness training like what homeowners should do in the event of a flood or how vulnerable are they to rising waters. When responders complete GIS training sessions, response times will increase and second-guessing should be eliminated. Having capable emergency
response teams prepared prior to an event will minimize confusion during an actual crisis situation.

Following a natural disaster, response teams only have a short time to react. Quick reaction times are imperative for natural disaster management. Responders will be able to determine the quickest way to their destination according to route identified in the planning stages prior to a flood using GIS TIGER (road) data. If additional support is needed, GIS can provide location information to the new arrivals. GIS can assist in natural disaster severity assessment. This valuable information determines the type of recovery efforts needed.

Recovery is an extremely important phase. After a natural disaster, the public safety is a primary concern and the goal becomes restoring the impacted areas back to normal. This can either be a short-term recovery process, which simply involves returning vital needs or it may be a long-term recovery commitment that can take several years, in some circumstances. GIS data can be used in this capacity to identify the vital areas that require immediate repair in order to restore some normalcy to the area. The extent and gravity of a disaster will dictate the recovery efforts. GIS can likely never eliminate the threat of these events but high-risk areas may be better prepared for if and when events do occur (Johnson, 2000).

Despite the noted advantages of utilizing GIS during a natural disaster, there are also limitations. These include the possibility of insufficient data, lack of organization, difficulty-recognizing deficiencies in models, problems with software and the inability to recognize needs of end users (Cova, 1999). The deficiencies in the system may be rectified with further investment in the preparation process. Management professionals need to maximize the capabilities of the program with additional training and research concerning its potential. Since natural disasters can change the structure of a city in moments, having comprehensive base data is imperative to saving lives and the surrounding environment. As cities, states and the federal government expand their GIS capacities, further solutions can be identified for the aforementioned limitations.

Geographic Information Systems are becoming more accurate and complete with software and technological advancements. The capabilities to compile data on both the ground and aerial levels are more advanced than in the past. This facilitates the availability of more detailed emergency preparedness systems for the future. Cell phones and computers are more capable of handling data than ever before. Utilizing enhanced software in these systems may pinpoint a disaster zone or inform GIS professionals through an open source system of less well-known areas. Online maps are being updated regularly as technology advances through satellite imagery. Making the most of the available information is key and as more people recognize the value and become skilled in the software, the database will be more complete and detailed. With ever-growing spatial information, GIS will become a more intricate part the management of natural disasters. This technology has and will continue to save lives, money and the environment.

This chapter offers further explanation of several aspects of GIS. There is a cycle associated with disaster management (planning, mitigation, preparedness, response, recovery). In the reading, the concept of combining the preparedness and response phases is a reoccurring theme. Another focus was the usage of the “reorganized” emergency management system to deal with sudden disasters. Human vulnerability is a large part of natural disaster management. As such, evacuation, according to the reading, is the “most effective response strategy available to emergency managers (pg. 854)”. To alleviate the potential fear or confusion associated with evacuation, managers must work, prior to an event, to create emergency planning zones (EPZ). However, due to the surprise of many disasters and difficulty identifying probable EPZs, it is more effective to focus on evacuation for an entire region through evacuation vulnerability mapping. Further research is being conducted that will make spatial management, GIS processes, more successful during these fast-paced, high-tension situations.


Evacuation procedures are a vital part after a natural disaster. This paper offers a detailed analysis on how evacuation routes are prepared to ensure the quickest and safest routes for the largest amount of affected civilians. Using a system called the “critical cluster model”, analysts are able to identify areas that may face difficulties during evacuation proceedings. GIS can aid in the evacuation process by linking human vulnerability and risk with extensive database information. The computer software is capable of configuring multiple safe and effective routes that are valuable before and during the evacuation process. In the reading, an evacuation plan for Santa Barbara, California demonstrates how basic Census and TIGER data can be combined to present planners with information used to create evacuation routes. Factors including time of day will alter the population in various areas. The type of potential disasters were also included in part of the studies but require further research since accounting for population variances are important in the spatial planning process.


This article coins the term “GI Science” as a combination of GPS, GIS, remote sensing and spatial analysis working cohesively to improve emergency management systems. A few problems associated with GI Science are identified. In order to increase effectiveness, GIS data needs to be simplified and useable for untrained responders, real time and up-to-date local infrastructure information is also imperative. Further GI science research can enhance response by offering estimates of the non-residential population, identifying potential future risks and vulnerability levels all of which contribute to more comprehensive information to first responders in an emergency situation. GI Science will only be successful if the user is informed and the spatial data is current. Ultimately, making information comprehensible for first
responders is imperative in the future of emergency management.


Public and environmental safeties are top concerns for any emergency manager. In the paper, the issue of vulnerability is addressed. Since the concern of vulnerability is objective, there is a difficulty conceptualizing a way to tackle the issue. With recent technological advances and increased availability, GIS has become an effective tool for government agencies as they seek to identify areas vulnerable to natural hazards in their locale. The compilation of information about the potential risks, the social response and vulnerable locations offers decision makers with a visual representation of what the priority areas are in the case of an emergency situation. Incorporating environmental and human vulnerability levels provides detailed data that can be used to create management plans that are effective across the spectrum of potentially affected resources.


The primary focus of this white paper is to lie out the process associated with disaster management preparation and execution. There are essential variables that must be assessed in a disaster situation where time is of the essence and every moment counts. Having a plan prepared in these situations is extremely helpful so that aid can be dispatched in a highly effective manner. GIS is a key component in the planning, mitigation, preparedness, response and recovery processes. Utilizing GIS in each phase allows departments and agencies to clearly communicate and quickly access the same, possibly vital, information after an event. Without detailed GIS data, responders would be unprepared to participate and may waste time gathering information that could have been primed before the event. Acquiring up-to-date data and have informed response teams can help alleviate some of the surprise associated with natural disaster phenomena. Additionally, this information can be used in training exercises for possible disaster scenarios.


In earthquake prone Cartago, Costa Rica where finances are tight, the government was in need of emergency management. This article considers how effective several different geospatial tools can coexist to provide quality information at a relatively low cost. As technology grows and evolves, tools become more effective and concise in their measurements or images produced. The ultimate goal of any emergency management plan requires initial organization, preparation, response and recovery. According to this guideline, a combination of Geographic Information System (GIS), Remote Sensing (RS), Global Positioning Systems (GPS) and Digital Video (DV) tools proved beneficial in Cartago at various stages in the process that offered detailed information for local decision makers. Utilizing these tools and the growing accessibility of mobile GIS systems, urban data can be compiled quickly and less expensively than actual field compilations. This case study demonstrated that mobile GIS is an effective way to obtain comprehensive information quickly about a highly populated, particularly vulnerable
city. With technological advances it is easier to execute this process today than ever before. These systems are particularly effective in developing countries because it creates an order of events to produce a comprehensive plan.


This paper demonstrated how effective remote sensing could be as a tool in the assessment both before and after a natural disaster. Depending on the situation, either satellites or aerial photography can be used. Aerial photography offers images very quickly at high resolutions over a small area while satellites using synthetic aperture radar, SAR, cover larger area but images can take weeks to develop. No matter how the method, once obtained images can then be compared to ones taken prior to the incident. The side-by-side assessment can provide details that may not be available on the ground level. They show the real time difference that are easy to interpret and any inconsistencies in a photo can be rectified to make analysis easier. After the Kobe earthquake in 1995, remote sensing was used to assess the situation. It was a valuable tool that offered high-resolution images of the affected area. Additionally, the combination of GIS and remote sensing through satellites proved crucial in the assessment in India after an earthquake in 2001. The extensive information allowed researchers to create a 3D model of the affected area using data from GIS and detailed satellite images. Utilizing the best features of each tool, GIS and remote sensing, comprehensive databases can be created which will provide future response teams with information that will aid in the development and execution of emergency management plans in the future.