GIS TECHNOLOGY: BOON FOR DISASTERS AND EMERGENCY MANAGEMENT

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ABSTRACT

Emergency management encompasses a wide range of activities. Government at all levels (national, state, and local) has primary responsibility for emergency management. Traditionally, the military has responsibility for threats from foreign governments. Lawmakers and policy makers are debating the appropriate role of the National Guard and military concerning internal terrorism. This paper will explain components and working of GIS, also identifies emergency management activities and describe how geographic information system (GIS) technology plays a critically important role in it.

Keywords: - *GIS, Disaster, Planning, Mitigation, Preparedness, Response, Recovery.*

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1. INTRODUCTION OF GEOGRAPHIC INFORMATION SYSTEMS

A geographic information system (GIS) is a computer-based tool for mapping and analyzing spatial data. GIS technology integrates common database operations such as query and statistical analysis with the unique visualization and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies. GIS is considered to be one of the most important new technologies, with the potential to revolutionize many aspects of society through increased ability to make decisions and solve problems.

The major challenges that we face in the world today -- overpopulation, pollution, deforestation, natural disasters – all have a critical geographic dimension. Local problems also have a geographic component that can be visualized using GIS technology, whether finding the best soil for growing crops, determining the home range for an endangered species, or discovering the best way to dispose of hazardous waste. Careful analysis of spatial data using GIS can give insight into these problems and suggest ways in which they can be addressed.

Map making and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving.

1.1 COMPONENTS OF A GEOGRAPHIC INFORMATION SYSTEM

A working Geographic Information System seamlessly integrates five key components: hardware, software, data, people, and methods.

Hardware/Software: Hardware is the computer on which a GIS operates. The software runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations. GIS software provides functions and tools needed to input and store geographic information. It also provides query tools, performs analysis, and displays geographic information in the form of maps or reports. All GIS software packages rely on an underlying database management system (DBMS) for storage and management of the geographic and attribute data. The GIS communicates with the DBMS to perform queries specified by the user.

Data: Possibly the most important component of a GIS is the data. A GIS will integrate spatial data with other data resources and can even use a database management system, used by most organizations to organize and maintain their data, to manage spatial data.

There are three ways to obtain the data to be used in a GIS. Geographic data and related tabular data can be collected in-house or produced by digitizing images from aerial photographs or published maps. Data can also be purchased from commercial data provider. Finally, data can be obtained from the federal government at no cost.

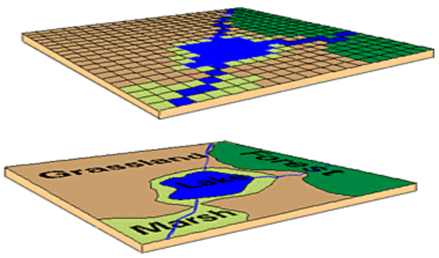
People: GIS users range from technical specialists who design and maintain the system to those who use it to help them perform their everyday work. The basic techniques of GIS are simple enough to master that even students in elementary schools are learning to use GIS. Because the technology is used in so many ways, experienced GIS users have a tremendous advantage in today's job market.

Methods: A successful GIS operates according to a well-designed plan and business rules, which are the models and operating practices unique to each organization.

1.2 WORKING OF GIS

A GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from modeling global atmospheric circulation, to predicting rural land use, and monitoring changes in rainforest ecosystems.

General purpose GIS's perform seven tasks.



- Input of data
- Map making
- Manipulation of data
- File management
- Query and analysis
- Visualization of results

Fig. 1

Input of Data: Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. The process of converting data from paper maps or aerial photographs into computer files is called digitizing. Modern GIS technology can automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitizing which requires the use of a digitizing table. Today many types of geographic data already exist in GIS-compatible formats. These data can be loaded directly into a GIS.

Map Making:

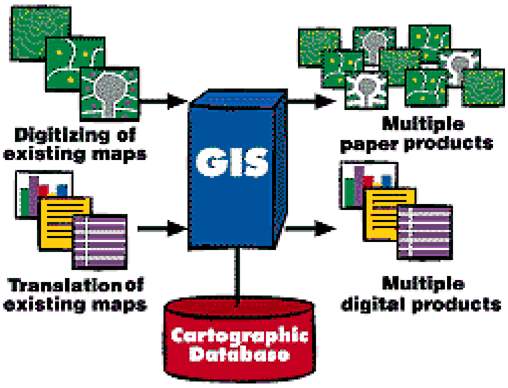


Fig. 2

Maps have a special place in GIS. The process of making maps with GIS is much more flexible than are traditional manual or automated cartography approaches. It begins with database creation. Existing paper maps can be digitized and computer-compatible information can be translated into the GIS. The GIS-based cartographic database can be both continuous and scale free. The characteristics of atlases and map series can be encoded in computer programs and compared with the database at final production time

Manipulation of Data: It is likely that data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with your system.

For example, geographic information is available at different scales (street centerline files might be available at a scale of 1:100,000; census boundaries at 1:50,000; and postal codes at 1:10,000). Before this information can be integrated, it must be transformed to the same scale. This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

File Management: For small GIS projects it may be sufficient to store geographic information as simple files. There comes a point, however, when data volumes become large and the number of data users becomes more than a few, that it is best to use a database management system (DBMS) to help store, organize, and manage data. A DBMS is nothing more than computer software for managing a database--an integrated collection of data. There are many different designs of DBMS's, but in GIS the relational design has been the most useful.

Query and Analysis: GIS provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information to managers and analysts alike. GIS technology really comes into its own when used to analyze geographic data to look for patterns and trends, and to undertake "what if" scenarios. Modern GIS's have many powerful analytical tools. Overlay Analysis integrates different data layers to look for patterns and relationships. For many types of geographic operations, the end result is best visualized as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and with multimedia.

2. DISASTERS AND EMERGENCY MANAGEMENT

Emergency management encompasses a wide range of activities. Government at all levels (federal, state, and local) has primary responsibility for emergency management.

2.1 General Types of Emergencies:-

Human-Caused—Human-caused emergencies include those unplanned events or accidents that result from human activity or human developments. Examples include chemical spills, nuclear radiation escapes, utility failures, epidemics, crashes, explosions, and urban fires.

Natural Disasters—Natural disasters include those unplanned events that occur as a result of natural processes such as earthquakes, tornadoes, tsunami, freezes, blizzards, extreme heat or cold, drought, or insect infestation.

Internal Disturbances—internal disturbances are those events or activities planned by a group or individual to intentionally cause disruption. This includes riots, demonstrations, large-scale prison breaks, and violent strikes.

Energy and Material Shortages—Emergencies as a result of shortages include strikes, price wars, and resource scarcity.

Attack—this includes acts of large-scale terrorism or war using nuclear, conventional, or biological agents.

2.2 Phases of Disaster and Emergency Management

Emergency management activities can be grouped into five phases that are related by time and function to all types of emergencies and disasters. These phases are also related to each other, and each involves different types of skills.

Planning, Mitigation, Preparedness, Response, Recovery

3. GIS—THE BOON FOR EMERGENCY MANAGEMENT

All phases of emergency management depend on data from a variety of sources. During an actual emergency it is critical to have the right data, at the right time, displayed logically, to respond and take appropriate action. By utilizing a GIS, all departments can share information through databases on computer-generated maps in one location. Without this capability, emergency workers must gain access to a number of department managers, their unique maps, and their unique data. Most emergencies do not allow time to gather these resources. GIS provides a mechanism to centralize and visually display critical information during an emergency.

Planning: Emergency management programs begin with locating and identifying potential emergency problems. Using a GIS, officials can pinpoint hazards and begin to evaluate the consequences of potential emergencies or disasters. When hazards (earthquake faults, fire hazard areas, flood zones, etc.) are viewed with other map data (streets, pipelines, buildings, residential areas, power lines, etc.), emergency management officials can begin to formulate mitigation, preparedness, response, and possible recovery needs. GIS facilitates this process by allowing planners to view the appropriate combinations of spatial data through computer-generated maps.

Mitigation: As potential emergency situations are identified, mitigation needs can be determined and prioritized. Values at risk can be displayed quickly and efficiently through a GIS. Utilizing existing databases linked to geographic features in GIS makes this possible. Where are the fire hazard zones? What combination of features (for example, topography, vegetation, weather) constitutes a fire hazard?

A GIS can identify certain soil types in and adjacent to earthquake impact zones where bridges or overpasses are at risk. A GIS can identify the likely path of a flood based on topographic features or the spread of a coastal oil spill based on currents and wind. More importantly, human life and other values (property, habitat, wildlife, etc.) at risk from these emergencies can be quickly identified and targeted for protective action.

Preparedness: Preparedness includes those activities that prepare for actual emergencies. GIS can provide answers to questions such as Where should fire stations be located if a five minute response time is expected? What evacuation routes should be selected if a toxic cloud or plume is accidentally released from a plant or storage facility based on different wind patterns? How will people be notified? Will the road networks handle the traffic? What facilities will provide evacuation shelters? What quantity of supplies, bed space, and so forth, will be required at each shelter based on the number of expected evacuees?

GIS can display real-time monitoring for emergency early warning.

Response: GIS can provide Emergency response units based at fixed locations can be selected and routed for emergency response. The closest (quickest) response units can be selected, routed, and dispatched to an emergency once the location is known. Depending on the emergency, a GIS can provide detailed information before the first units arrive. For example, during a commercial building fire, it is possible to identify the closest hydrants, electrical panels, hazardous materials, and floor plan of the building while en route to the emergency. For hazardous spills or chemical cloud release, the direction and speed of movement can be modeled to determine evacuation zones and containment needs.

Recovery: Recovery efforts begin when the emergency is over (immediate threat to life, property, and the environment). Recovery efforts are often in two phases, short term and long term.

Short-Term Recovery-- This may include temporary food, water, and shelter to citizens who have lost homes in a hurricane or large wildfire; assuring injured persons have medical care, and so forth.

A GIS can work in concert with GPS to locate each damaged facility, identify the type and amount of damage, and begin to establish priorities for action. GIS can display (through the primary database) overall current damage assessment. Emergency distribution centers' supplies (medical, food, water, clothing, etc.) can be assigned in appropriate amounts to shelters based on the amount and type of damage in each area. GIS can display the number of shelters needed and where they should be located for reasonable access.

Long-Term Recovery-- Long-term recovery restores all services to normal or better. Long-term recovery (replacement of homes, water systems, streets, hospitals, bridges, schools, etc.) can take several years. Long-term plans and progress can be displayed and tracked utilizing a GIS. Prioritization for major restoration investments can be made with the assistance of GIS. Accounting for disaster costs can be complicated. As funds are allocated for repairs, accounting information can be recorded and linked to each location. Long term recovery costs can be in the millions (or more) for large disasters. Accounting for how and where funds are allocated is demanding. A GIS can ease the burden of this task.

4. SUMMARY

Emergency management programs are developed and implemented through the analysis of information. The majority of information is spatial and can be mapped. Once information is mapped and data is linked to the map, emergency management planning can begin. Once life, property, and environmental values are combined with hazards, emergency management personnel can begin to formulate mitigation, preparedness, response, and recovery program needs.

Historically, emergency management programs are planned, implemented, and modified based on volume of business or reaction to emergencies as they occur. GIS allows emergency management needs to be identified prior to an incident. Emergency management personnel can use modeling for training, for actual tactical deployment during a disaster, or to analyze the consequences of a possible disaster. The use of this technology takes emergency management planning information off the shelf for utilization by response personnel for real-world operations. In short, the thoughtful application of a GIS can take much of the panic and surprise out of emergencies.

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