Disaster management practices using ArcGIS, ArcIMS, ArcSDE and Oracle

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Abstract

Emergency preparedness for disaster management is a crucial segment wherein administrators, planners, managers and stakeholders play an important role. For emergency preparedness and disaster management the dynamic representation of spatial and aspatial data in a web enabled GIS environment is the mark of the day. Dynamic representation of spatial and aspatial data, inputting data from client side and identifying its pros and cons, planning/decision making upon the information/data collected, administering the entire scenario could be done in many different ways, but the right technology that proves its uniqueness, is the integrative development of web enabled GIS. Keeping this in mind, web enabled GIS techniques were used to meet the emergency preparedness for nuclear, chemical and many other disaster management practices. Technology adopted for developing the modules and its application potentials were explored and briefly discussed.

Keywords

Emergency – GIS – Web Technology – Nuclear – Chemical – Disaster Warning System – Disaster Management

Introduction

Emergency management is a dynamic process. Emergency preparedness for disaster management is the process of preparing, mitigating, responding, and recovering from any emergency situation. Individuals and organizations responsible for emergency management use different tools to save lives, reduce human suffering and preserve economic assets before, during and after any catastrophic event. But nowadays, correct and timely information is a critical part of any successful emergency management program. The unique tool for emergency purpose is a web enabled Geographic Information System (GIS), which could provide accurate and timely information.

Generally, disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it. Disaster is an event "… meeting at least one of the following criteria: kills 10 or more persons; affects 100 or more persons; leads to a declaration of state of emergency; or leads to call for international assistance." Disaster also involves humanitarian emergency, humanitarian actions, mass casualities etc. Effective disaster management requires rapid decisions and actions on behalf of relief workers. The scope of disasters is large (in terms of the number of people affected) and also the most important thing is the lack of resources to manage disasters.

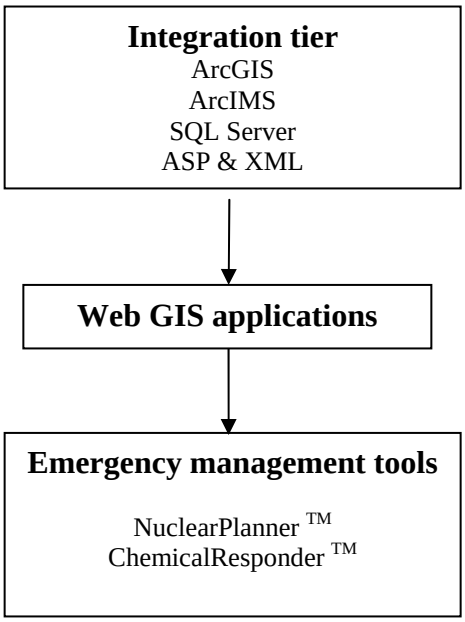
Disaster management in developing countries exists within a complex political, social and economic environment, where a coherent and coordinated approach can be difficult to implement. As such, large-scale high magnitude – low frequency disasters will continue to overwhelm local disaster managers, prohibiting effective management, particularly during the response phase. Although most natural disasters cannot be prevented, disaster losses can be minimized when appropriate actions are taken which utilize the latest technology and real-time spatial data/information. Through GIS and remote sensing we can make data / information available, and answer questions concerning the spatial and temporal dimensions for disaster management.

In today's information technology disaster management rely on IT tools such as GIS, electronic mail, document sharing, web and database access. GIS database can be accessed for damage assessment or to locate critical infrastructure such as chemical facility that needs to be inspected and secured. High resolution images or video sent in a real-time situation from a remote location can allow experts to assess damage. Henceforth, GIS integrated with IT presents significant opportunities to greatly improve the effectiveness of emergency management.

Recently, the internet is gaining popularity as a mechanism that can facilitate the exchange of information/data (spatial and non-spatial) in time to warn a disaster. Initiatives such as the Global Disaster Information Network (GDIN) provide evidence of the importance and the value of disaster – related information, as well as the need to obtain and share it effectively. The aim of GDIN is to "provide the right information, in the right format, to the right person, in the right time to make the right decision" (GDIN, 2005). Spatial decision support systems, commonly considered as application specific software solutions (Rinner, 2003), are used in solving complex spatial problems where alternative decisions needs consideration. Wellar (1990) and Crossland et al. (1995) showed that the use of GIS as a type of Spatial Disaster Support System (SDSS) reduced the decision time and increased the accuracy of individual decision-makers, while Peng and Tsou (2003) the power and benefits of GIS. Integrating these technologies in an online, GIS based SDSS has the potential to increase the use and accessibility of spatial data, as well as the accuracy and efficiency of decision making, thereby improving the effectiveness of disaster response.

Hence for emergency preparedness and disaster management, GIS domains such as ArcGIS, ArcIMS, SQL Server and ASP were integrated and explored. Modules pertaining to emergency management were also developed by integrating the knowledge of experts, managers, programmers and developers, web enabled GIS techniques were used to manage nuclear, chemical, natural and many other disasters. These web enabled GIS based applications provides salient features for hazard alert, emergency response, emergency management, leverage investment, facilitates emergency alerts, periodic situational updates, community notifications, service disruptions, interagency coordination, e-Government solution and so forth. Its design, plan and its functionalities were elaborately discussed below.

Methodology



Results and Discussion

Web Technology for Emergency Management

GIS system integrates ArcGIS, ArcIMS, SQL Server and ASP domain networks to form a web-based emergency preparedness / management system. Both spatial and aspatial were kept in GIS database. Coding for information retrieval, search capability, feature extraction were carried using ArcIMS and ASP. All the Objects, Methods, Modules and Components available within the software environment were utilized effectively, coded and programmed. The application is developed as a web enabled GIS on Microsoft Windows Platform. In all the applications for disaster management, Maps are the primary output of the system which, when displayed on computer screens, are more dynamic, potential and versatile (Alexander, 1991). This system complies with Coppock (1995) who points out that the technological developments intended for use in developing countries must be kept simple, considering the skills (both technical and bureaucratic) and resources available. The tools available in the webGIS applications and its features towards emergency management are formulated similarly. The potential of webGIS tools for nuclear, chemical and natural and many other disasters were discussed as follows.

Nuclear Disaster

Although construction and operation of nuclear power plants are closely monitored and regulated by the nuclear regulatory authorities, accidents, though unlikely, are possible. The most immediate danger from an accident at a nuclear power plant is the exposure to high level radiation.

Emergencies declared for nuclear power plant are defined in terms of notification of unusual event, alert, site area emergency and general emergency. Notification of unusual event means a problem has occurred at the plant, but no radiation leak is expected. Alert means that small amounts of radiation could leak inside the plant, but it will not affect the community. Site area emergency describes a more serious problem. Small amounts of radiation could leak from the plant. Area sirens may sound. Citizens are requested to listen to radio or television for instructions and be prepared to evacuate or find shelter. For addressing the above issues an emergency preparedness plan for nuclear power plant is developed using the recent scientific web enabled GIS technology.

The NuclearPlanner^{TM}, a web GIS based application tool, provides a web-based evacuation preparedness for citizens living close to nuclear power plant, within the 10 mile radius. This is an important tool for strengthening relations with the community by reaching out to citizens with updated information and proactive planning tools. This delivers personalized response information to identify appropriate evacuation routes and response measures. Citizens living in risk area can identify their emergency reception centers, driving directions, and emergency exits. The system can also be integrated with weather, demographic data and real-time highway database and could help planners to evacuate peoples during the crucial time of natural disasters. Its major components includes end to end web-based solution, feature query, proximity analysis, emergency response plan module, evacuation routing module for public emergency, property query module, theme add in and on/off module, buffer analysis etc.

Chemical Disaster

Hazardous material are chemical substances, which if released or misused, can pose threat to the environment. These chemicals are used in industry, agriculture, medicine, research, and consumer goods. As many as 5,00,000 products pose physical or health hazards and can be defined as “hazardous chemicals.” Each year, over 1,000 new synthetic chemicals are introduced. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents in manufacturing plants.

In the early hours of Monday, Dec 3, 1984 a toxic cloud of methyl isocyanate (MIC) gas enveloped the hundreds of shanties and huts surrounding a pesticide plant in Bhopal, India. Later, a deadly cloud slowly drifted in the cool night air through streets in surrounding sections, sleeping residents awoke, coughing, and rubbing painfully stinging eyes. By the time the gas cleared at dawn, many were dead. Four months after the

tragedy, the Indian government reported the parliament that 1,430 people had died. In 1991 the official Indian government panel charged with tabulating deaths and injuries updated the count to more than 3,800 dead and approximately 11,000 with disabilities. Considering the importance of emergency preparedness for these chemical disasters a webGIS tool Tier II Manager ^{TM} is developed.

This is a user friendly comprehensive tool developed to streamline the process of meeting emergency planning and emergency response needs. This provides a real-time access to critical hazardous chemical inventory and facility information. It addresses the needs of first responders, emergency response planners, facility submitters, and state authorities. Vulnerability reports, demographic reports, notifications, and payment modules make this system more valuable. This is ensured with multiple levels of security to appropriate groups in order to have access for appropriate data and functionality.

It streamlines the process of chemical inventory reporting. Chemical storage facilities can submit regulatory and planning information through a set of simple on-line forms. In following years, the facilities can revise the existing information anytime, significantly reducing the expense of repeating the entire submission process each year. Planners can access real-time information to create emergency response plans and carry out comprehensive oversight activities. When rapid response is necessary, first responders can map all chemical storage facilities and instantly retrieve other supplemental information like site plans while mobilizing toward the emergency site. This provides a comprehensive, cost-effective way to meet regulatory requirements and provides emergency response information at the critical moment decision-making in no time. Its major components includes end-to-end web-based solution, chemical storage facility analysis tool with respect to infrastructure and demographics, automated authority level query tool for spatial planning, query tool for an extensive database – data retrieved in seconds and as an add-in for any back-end database platforms. For first responders, the application can be deployed wirelessly or as a standalone version, covers non-coverage areas and it also possess hierarchical level security for end users.

Disaster Warning System

As population and housing densities increase, the world continues to experience ever increasing danger and damages from natural and man made disasters. Deaths, injuries, and loss of property will increase around the world due to disasters, unless changes are made in the manner we respond to disasters. Most experts in disaster claims that the world's population is at an ever increasing risk of death, injury, and property damages from disasters. Hence to notify the disaster and to minimize the risk a webGIS based Disaster Warning System, is developed.

This Disaster Warning System is aimed to continuously alert the most geographically appropriate emergency response personnel such as rescue, fire, police, and ambulance personnel, to allow much quicker and more accurate first response efforts and further reduce disaster impacts on lives and property.

Combining the power of GIS mapping analysis and notification capabilities, the system facilitates end-to-end response and recovery. It helps to analyze a situation, send out calls, and collect responses from thousands of people in an hour using flexible standard based tools. DWS differs from any location with an internet connection, providing powerful decision-making and proactive notification capabilities.

It brings together the best in speech technology with the power of mapping through GIS to provide Emergency Response Managers with the speed and flexibility to meet even the most challenging notification scenarios. It is developed using XML technology which provides an open standard that the Emergency Response community has been seeking. The easy-to-use application can be assessed by multiple agents from any location though a simple internet browser. With a set of personalized passwords, responders can customize a set of standard response forms, choose the targeted area for the notification using a simple GIS interface, and initiate the call. Recipients can hear the message spoken. The system can conduct dialog, map and collect critical response information, and trigger alerts and other dispatch. Easy-to-read reports, help one to rate and understand the notification, performance, identify which calls were answered, which ones never reached their intended recipients, and which recipients need help. It combines technologies to enable informed decision-making and communication when crucial situation exists. Its major components includes interactive mapping, speech and text-to-speech recognition, voice recognition, real time critical responses from clients, real time GIS mapping and multi-modal response, system interoperability and to communicate by using the advantage of XML.

Conclusion

Thus for nuclear, chemical and natural disaster webGIS based tools such as NuclearPlanner^{TM} and ChemicalResponder^{TM} will be very useful for emergency preparedness and disaster management practice. The paper also reveals that the web enabled GIS technology has got its unique potential for emergency preparedness management. These web enabled tools currently serve as a national and international application tools for emergency preparedness and disaster management. These tools were further upgraded by processing insitu data to increase the efficiency of disaster mitigation and management. The recent scientific tool, Disaster Warning System developed in webGIS environment is also in upgradation for proposing an effective disaster management plan in near future. Any now this tool is being upgraded in ArcGIS Server environment.

Acknowledgement

I thank all my colleagues for getting associated to carry out emergency management practice. Earlier, the entire system was just in an information system but based upon R & D integration and my expertise knowledge in these areas this information system was upgraded as an emergency management system for US.

Reference:

Alexander D (1991) Information technology in real-time for monitoring and managing natural disasters. Process in Physical Geography 15(3): 238-260.

Coppock T J (1995) GIS and natural hazards: an overview from a GIS perspective. In: Carrara A, Guzzetti F (eds) Geographical Information Systems in assessing natural hazards, Netherlands, Kluwer academic, pp 21-33.

Crossland MD, Wynne BE, Perkins WC (1995) spatial decision support systems: An overview of technology and a test of efficacy.Decision support system 14:219-235.

GDIN (Global Disaster Information Network) (2005) GDIN Homopage. htpp://www.gdin-international.org/

Peng ZR, Tsou MH (2003) Internet GIS. New Jersey, John Wiley & Sons, Inc.

Rinner C (2003) Web-based Spatial Decision Support: Status and Research Directions. Journal of Geographic Information and Decision Analysis 1(7): 14-31.

Wellar B (1990) Science, Applications, Coherence and GIS: Seizing the Moment. GIS/LIS ’90 Proceedings, Volume 2, 855-871.